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THE PSYCHOLOGICAL REVIEW

COMMUNICATION, CORRESPONDENCE AND CONSCIOUSNESS

BY S. BENT RUSSELL

St. Louis, Missouri

When a muscle of a man's body contracts, the operation is due, as almost every reader knows, to a molecular disturbance that is propagated through a hair-like nerve fiber from the brain or spinal cord. He knows also that similar impulses travel from the sense organs to the brain. It seems to be commonly believed, however, that the brain can originate some of these movement-exciting impulses. Prevailing methods of education have led most men to look at mental processes from the subjective side and to judge of the thoughts and feelings of others as like their own. At this date we can find but a small number of men who have given sufficient study to mechanistic theories of thought processes to be able to discuss them intelligently. Among those who have studied these matters, we find men who admit that reflex action is a case of nerve mechanism but do not concede that reason and purpose are similarly constituted. The general idea is, we may say, that at one end of the scale we have the simple mental processes which are nervous impulses in operation and at the other end we have the highly complex mental processes, presided over by the inner consciousness.

The question then arises as we approach the upper end of the scale, what part is taken by the nervous mechanisms? When consciousness is most complete, what is occurring in the nerve fibers? The answer to this question may be taken as the goal towards which we will work in this discussion.

When a boy can faithfully describe in language his present environment and recent changes in his environment, we can say that he has a conscious mind. In such a case we may assume that the real environment of the boy is known to ourselves, the observers, as we can change it at will and as our minds are more fully developed than his. From our knowledge of physiology we know that his consciousness is in some measure dependent on operations in his brain and nervous system. Let us then consider briefly these operations.

We know that when a feature of the environment is in communication with a part of the brain that there is first an outer communication of the feature with a sensory nerve ending and second an inner communication from the nerve ending to the brain. We may look at the matter as if there were an outer environment made up of real objects and an inner environment representing the outer environment and located at the nerve endings. For example a vibrating bell is of the outer environment but the sound vibrations in the inner ear are of the inner environment. We may then think of the environment of an individual as two zones. Let us call them the 'near zone,' which is at the nerve endings, and the 'far zone,' which is all outside. We will now take up the near zone as acting on the brain.

There are special nerve endings in the skin for heat and others for pain. It is known that if the nerve fiber is cut, there is no longer any sensation of heat when the nerve ending is heated in one case and no sensation of pain when the pain receptor is stimulated in the other. In order that there be a sensation, the nervous impulse must reach the brain. It seems probable that the propagated impulse from a pain receptor is very much like one from a heat receptor. How then does the brain discriminate between the heat signal and the pain signal? We may find a parallel case in the telephone instrument. Electric impulses pass over the wire and one impulse is like another and yet we get widely different sounds from the receiver. We can readily distinguish the sound of the fife from that of the drum. The sound in the receiver

simulates the sound in the transmitter. On looking into the case we find that by the mechanism of the transmitter the sound waves are transformed into electric impulses and by the mechanism of the receiver the electric impulses are transformed back into sound waves. Let us consider if similar transformations take place within the nervous system. We find that by the mechanism of the ear sound waves are transformed into nervous impulses. We find likewise that light, heat and electricity are transformed at the proper receptors into nervous impulses. By the organs of taste and smell, chemical action is converted into nervous impulses. Dynamic force also, of course, is converted into nervous impulses. All of these transformations we know are made with the organs of sense.

The question then arises, can these transformations be reversed? Can nervous impulses be transformed into sound, light, heat or electricity or into chemical action or dynamic force? We find that they can be, provided suitable mechanisms exist. Nervous impulses produce sound in the vocal apparatus just as well as electric impulses produce sound in the telephone receiver. There is little doubt that in the lightning bug there is an apparatus by which nervous impulses cause light, and that in the electric eel there is an apparatus by which nervous impulses cause electricity. Without going into this matter more fully, let us consider it settled that by suitable mechanisms, nervous impulses can be transformed back into all the familiar forms of energy. It follows then that if there should be suitable mechanisms located at the brain centers, the nervous impulse would be converted into heat for example, or into other forms of energy. The next question for us to consider then is this: Have we any reason to suppose that there are mechanisms in the brain centers which can transform nervous impulses back into the form of heat, etc.? Our knowledge of the physiology of the brain cells is very limited. We find there is some reason to think that chemical change, heat and movement at least, occur in the cells. One might argue also, that if there can be movement produced in a cell,

something like a sound wave might be caused. One might argue also that light and heat are near of kin.

As a result of this brief survey of the matter we may conclude that it is conceivable that nervous impulses are, at the brain centers, transformed back into sound, heat, etc., but it is not probable. It is thought fair to assume, however, that afferent impulses are at the brain centers transformed to some extent into different forms of molecular movement. We may assume also that there is a certain form of movement for sound and another for heat and another for pain, etc. There is then, we will say, a mechanism at the brain center that acts like a telephone receiver and transforms the afferent impulses into a form of molecular movement that in effect simulates the stimulus at the sense organ. It is by aid of this central mechanism then that the brain discriminates between the heat signal and the signal of some other sense.

We may suppose that this central mechanism is something on the same plan as we assume to be in efferent nerve endings at the effectors of the body, such as a tear gland for example. Or, looking at it another way, we may suppose it as the obverse of the mechanism at the receptor where the nervous impulse originates. In other words we will assume that in the case of a signal from a heat receptor, there is a molecular disturbance at the proper brain center which is the same as if the heat were applied to the brain center itself. In the case of vision we will assume that the molecular change at the brain center is the same as it would be if a ray of light should penetrate it. In the case of sound, the change at the brain center is the same as if the sound vibrations reached it. In the case of taste, a drop of acid on a taste receptor makes a change at the brain center the same as if the acid were applied there. In smell the same rule will hold.

In other words in all afferent impulse cases there is a change in some brain center that in effect reverses the process that occurs at the nerve ending. In short whatever transpires at the near zone transpires in effect, as we will assume, at appropriate brain centers. Let us carry the idea out and suppose that a kinæsthetic impulse from a moving

muscle to the brain causes a molecular movement in the proper brain center that is very much like the change taking place in the substance of the muscle. So the change in the muscle does in effect take place also in the brain center. Let us carry the idea out farther and suppose that the process is reversed for all cases of efferent impulses from the brain to the effectors. There is a change or movement in the brain center that is simulated in the muscle or gland at the nerve ending. Considering a whole circuit, we see that if a pain receptor is stimulated there will be a wound effect process at the brain center which will provoke a molecular movement that sends an efferent impulse to a muscle which will have a simulating molecular movement that will cause the muscle to contract.

It is true of course that in exceptional cases the change in the brain center does not simulate the change at the nerve ending, as when a pressure on the eyeball gives a sensation of light. We may pass them by as too exceptional to be of consequence in this discussion.

To proceed: let us now think of the effect of the environment on a creature of the lowest intelligence. Let us assume a tadpole-like animal on a sandy beach. It will have rudiments of a head, of a tail and of one leg on each side. It may be surrounded by sand, by water or by air, or be partly in one, partly in another element. It has a cerebral ganglion that we will call the brain. In the brain there will be a certain area for the tail and an area for each leg. When the tail is in the water, certain brain fibers will be made active; when it is in the sand, other fibers will be aroused. The environment of each limb will be manifested in the brain by the activity of certain nerve fibers. So for every situation there will be a simple simulating process that is characteristic. As already shown it is allowable to assume that the disturbance in the brain is an echo of the disturbance at the leg or tail. The brain is then so constituted that it automatically adjusts itself to the environment. Of course in the human brain, the operations are much more complex.

As a sort of starting point for this discussion let us pred-

icate that in a creature having a cerebral cortex, if a unit feature of the environment is represented at the near zone, there will be communication to certain nerve fibers in a sensory area of the brain and there will be a unit change in those fibers which simulates in effect the change in the near zone. Of course in life there are always many features simultaneously represented in the near zone and therefore acting together upon the brain in question. It helps us to get a clear idea, however, to think of a unit feature as a cause and a unit nerve change as an effect. Whatever that is present at the near zone is simulated in effect in the nerve centers. As between the near zone and the brain we have communication and simulation and we may believe that the process is a simple one. We shall find that the far zone is also simulated to some extent in the cortical centers, but, as we shall see later, the process is much more complex. An understanding of how the near zone is simulated helps us to understand how the far zone is simulated.

It is true, of course, that the sense organs or more especially the distance receptors are highly developed mechanisms of communication between the far zone and the near zone of the environment. We may consider that the functions of these mechanisms are understood and have been explained by physiology. Rays of light and waves of sound are by these means utilized for communication. We shall see later how association mechanisms provide for the accompanying simulation of the far zone.

When a child is conscious of its environment, there is a disturbance in its brain that, as we shall see, simulates the far zone. The child is conscious of what it touches, what it sees, what it hears, what it smells, what it tastes. That part of the far zone which is in active communication with the brain is simulated by the disturbance in the brain centers. The child is not conscious of a change in its ear drum or retina. If the child is listening to a phonograph the sound is located at the phonograph and not in the ear. When the child is conscious of an object there is a communication between the object and the child's brain. There is also, as above stated,

a simulation of the object in the brain. These are two important operations, we see, communication and simulation.

To make the point clearer, let us say that *AA* is a feature of the far zone that is in communication with our subject. Let *Aa* be the feature as represented at the near zone. Let *A* be the change that takes place in the nerve fibers due to the excitation coming from *Aa*. In the same way let *BB* be another feature of the far zone, *Bb* be the feature as represented at the near zone, and *B* be the effect on the nerve fibers. Let *CC* be a third feature of the far zone and *Cc* the same at the near zone and *C* be the effect and so on. The case can be shown by a simple diagram as follows:

Environment

Far Zone	Near Zone	Cortical Centers
AA	*Aa*	*A*
BB	*Bb*	*B*
CC	*Cc*	*C*
DD	*Dd*	*D*

The dotted lines represent the paths of communication between the environment and the brain centers.

For the sake of clearness and brevity in this discussion, let us use the term 'mimetic process' to express the operations that occur in the brain of an individual when he is conscious of his present environment. Let us also use the term 'image process' to express the operations of his brain when he is conscious of his past environment.

To proceed: let us think of a man and of his shadow on the wall. As the man moves, the shadow moves. We see that there is a correspondence between the shadow and the real man. Now think of a child observing the man. There is a pattern of the man in the child's brain something like the shadow on the wall. If the man moves there is a change in the brain disturbance.

To illustrate the idea more precisely, let us think of a case in photography. We will suppose a dimly lighted furnished room and in it a double camera for stereoscope pictures. We adjust the focus, put in a pair of sensitive plates and open the shutters. Owing to the dim light a long-time exposure is needed to make a good negative. If

we were now able to observe the change going on in the sensitive film, we would find a correspondence between the molecular or chemical change and the features of the room. Let us for convenience use the term 'film process' to express the change that is taking place in the film. We may say that the film process corresponds with the environment. We can almost say that the film is conscious of the environment.

Now if the lenses are good and their focus is right, the correspondence will be good. So we see that the degree of correspondence depends upon the quality of the lenses and the correctness of the adjustment. For want of a better expression, let us use the term 'degree of verity' to express the correspondence of the film process in the two plates with the features of the room as they actually are. If we close the shutters, the film process ceases. As communication is cut off the correspondence stops. It is then a case of communication with simulation.

To compare with this let us think of a child looking into another furnished room. There will be in the child's brain a molecular change that corresponds with the view of the room. This change is the mimetic process. It is something like the film process in the camera plates. The degree of verity in the mimetic process will depend upon the correctness of vision, the illumination and other matters to be considered later.

Let us remember the scientific principle that like causes produce like effects. In the case of the double camera, a like environment will give a like film process. In the case of the child, a like environment will give a like mimetic process. Thus do we get correspondence of the brain process to the situation. Remember also that the child is not conscious of the changes in the organ of vision or brain centers, but only of the things represented by the mimetic process.

To get an idea of the image process, let us take a different case and think of a child that is observing a man in the first instance. There is a corresponding mimetic process in the child's brain. The child is conscious of the man. At another time suppose that, from some cause, the same process occurs

completely in the child's brain although the man is not present. The child is conscious of the man when there is no man. This, then, is an illusion. When the child has a memory image of the man the brain process is not entirely complete as in the case of an illusion. We may say that a memory image is, as it were, a partial illusion. The incomplete brain process is, as we have said, the image process. Or to take a different view, let us say that when the child has a memory image of the man, there is a secondary brain process that simulates the original mimetic process and so indirectly simulates the object (man) seen in the past. This secondary process is the image process.

In further illustration of these matters, let us think of a child taking a long walk. As he proceeds along the path, he is conscious of the changes in the environment as they are presented. It will sometimes happen, however, that the child is conscious of the environment at a point some distance back on the path instead of that where he is walking at the moment. This will usually occur when the child observes some feature of the road that resembles one that he has met at the point further back. The sight of the third mile post may cause him to recall a gateway that he saw at the second mile post. We have then an image process, we may say, that simulates a past environment although there is now no direct communication between that environment and the brain. This is the work of nervous mechanisms, or perhaps of nerve-muscle mechanisms.

To explain more definitely, we may say that the sight of the third mile post provokes a short series of changes in the nerve-muscle system that produces afferent impulses similar to those caused by the sight of the gateway at the second mile post. In this way is the child made conscious of his past environment. Observe that the child is not conscious of any changes in his nerves or muscles. He is conscious of the gateway, now a thing of the past.

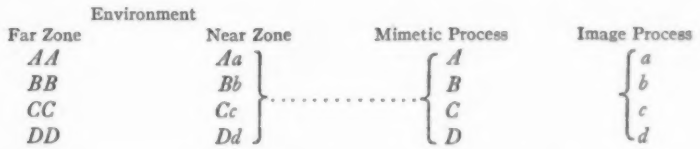
By way of further illustration and explanation, think of looking at a picture in a stereoscope. You do not see the two prints, you seem to see real objects in perspective. By

means of the devices peculiar to the instrument, an artificial mimetic process is provoked in your brain centers and the illusion is perfect. You are thus made conscious of an environment as though you saw it in reality. You see a monument, for example, where in reality there is no monument. It is the same way with a memory image. For instance, you are conscious of a scene of boyhood days. Some association fibers in your brain have been stimulated as though by the device of the stereoscope and for a moment you are conscious of the past scene.

It is the same way with the child in our other illustration. Ask the child what he has seen along the road and he will describe the gateway, showing that he is conscious in some degree of features in the environment that he passed through. In order that the child may recall the gateway, he must have been conscious of the gateway before and he must have mechanisms of associative memory that produce a stimulation of the same brain centers as were affected by observing the gateway.

On consideration we find that when a child is conscious of its present environment it is because the environment is in direct communication with the child's brain and there is a resulting correspondence of the brain processes with the environment. We also find that when the child is conscious of a past environment, it is because some stimulus has provoked a recurrence or simulation of brain processes that were previously produced by that environment.

We can make the whole matter clearer by the use of symbols. Let *AA* at the far zone and *Aa* at the near zone be a feature of the environment that was in communication with our subject in the first instance. Let *A* be the change in the cortical fibers due to *Aa* and let *a* be a change that is similar to *A* which comes at a later time and is provoked by an association fiber. Other features of the far zone will be *BB*, *CC* and *DD*, represented at the near zone by *Bb*, *Cc* and *Dd*. The correspondence nerve changes at the time will be *B*, *C* and *D*, and the subsequent changes will be *b*, *c* and *d*. By a simple diagram we have:



Let us remember that it is the object that makes the mimetic process and that it is the object that is known to the conscious subject.

Looking further into the matter, we find a great variation in the degree of verity, *i. e.*, in the degree of precision and definiteness of the correspondence of the brain processes with the actual environment. There is good reason to think that the verity increases with training, and education.[1] We know that a man notices objects that a child does not and that an educated man notices objects that would escape the observation of an uneducated man. Think of an engineer and a shoemaker looking at a steam pumping engine. The brain correspondence of the former will be much more precise and definite. On the other hand the savage sees the track of a wild animal that is invisible to a white man.

The increasing degree of verity of the mimetic process that comes from training is partly due to better communication from the environment to the brain, especially in the case of vision. The fixation and focusing of the eyes is a matter of practise. Discrimination with any of the senses increases with training. On consideration we see that the degree of verity keeps pace with the formation of memory associations, *i. e.*, with the growth of habits. After an object has become familiar to you, you can no longer see it as you did at first sight. We may say, then, that the degree of verity of the mimetic process is largely determined by mechanisms of associative memory.[2] To put it another way, unless the association nerve paths have been prepared by previous experience, the brain process will not simulate the environment. Knowledge of the present environment is dependent on associative memory. When you look up the street on a

[1] James R. Angell, 'Psychology,' Holt, New York, 1908, p. 176.

[2] W. B. Pillsbury, 'The Fundamentals of Psychology,' Macmillan, New York, 1916, 341, 342.

bright day and are conscious of trees in the foreground and of a church spire in the distance, your power of coördinating the scene is due to physical conditions and to a long course of training and experience.

It may help you to realize this if you take a new magazine and look at the pictures upside down. Many of them will appear meaningless. To an untrained mind, a dog's for example, the pictures would be equally meaningless when right side up. We may believe that in the untrained mind the correspondence is a confused one. It may be something like one's impressions while looking at a four-ring circus.

In this connection we may observe that the reason a boy is conscious of the words of one speaker only in a room where others are talking, is because the mechanisms of associative memory make up the mimetic processes that correspond with the words of the one. The speaker that he hears is usually the one he has been watching.

For the purposes of this discussion we will say that association nerve fibers are dual common paths, each having two tributary connections that are sometimes excited in sequence and thus the common path is made more open for impulses that control behavior. So when the child is conscious of an object, we know that the object is exciting certain nerve receptors and it transpires that a volley of impulses must be following a certain group of association fibers (common paths) that have been developed by previous operations.[1] The greater the number of these fibers that take part and the more highly developed they are by previous operations, the greater will be the degree of verity.

We can only judge of a creature's intelligence by its behavior. We cannot be sure that a child is conscious of its environment unless it gives expression to its feelings by some response. It is not until a child has learned to talk that we know much about his mental activities. We say a child is observing because he gives expression to impulses provoked by his environment. On the other hand if a child does not notice changes in his environment, we say he is unconscious.

[1] Angell, *op. cit.*, p. 169.

It follows then that our discussion should include some consideration of expression and of its relation to correspondence and consciousness. We may find that the employment of language increases the degree of verity. Suppose a child is observing a squad of soldiers. You ask him to count them. When he has done so and answers 'Five', you may know that his brain correspondence has increased. At the same time that a child is learning to talk, he is learning to give expression to his experience. There can be little doubt that this sort of training has an important effect in raising the degree of verity in the child's brain processes. By the time the child can name every object in the nursery, he has acquired a high degree of verity with that particular environment. In the same way when he learns to draw from a model, the effect is to raise the degree of verity with visible objects. Let us note that learning to talk or draw pictures is the development of mechanisms of associative memory. It is the result of training. The studies of mathematics, weights and measures and geometry must have an important effect in raising the degree of verity of the mimetic processes. When a group of children are sight-seeing together, they remark on what attracts their attention. Thus they acquire habits of expression which affect future mimetic processes to an important extent. It is safe to say that in the minds of many men, thinking is only incipient talking, as it were, for at least the greater part of the time. We find then that language is clearly an important factor in the development of brain correspondences.

We have already remarked that the coördination of mimetic and image processes is a matter of associative memory. In young people the correspondence of the consciousness with past and present environment is an increasing one. New concepts are constantly being acquired. We may suppose by way of illustration that the first clear correspondence is with the environment of the nursery. The child has a concept of the room and its furnishings that is independent of the sensations of the moment. No matter what direction the child faces, the room still seems to him the same place. In

consequence of a vast number of associations, the concept has been established. Having this concept to start with, new concepts are joined to it, so that by gradations the house, the yard and the street are annexed in the mimetic processes. The field grows wider and wider, taking in the school, the church and the park, etc.

When a man returns to his home and recognizes it, there is a particular group of association fibers "wakened up" in his brain. When he enters his room if he is conscious of the room, there is a particular group of nerve fibers wakened up, no matter which door of the room he enters by. The mechanisms by which this is done have been built up step by step. We may say that in recalling a certain room, there are incipient movements made that would actually be made in observing the features of the room and in giving expression to them by word of mouth, or, if one is an artist, by drawing or painting them. To look at it another way, a concept of a certain room is a composite picture of all one's past experiences in that room. Each experience developed certain common nerve paths which are now in use.

To look at it again from a little different angle, we may say that the first time an object is seen, attention movements are made. The object is examined, felt, smelt, tasted, viewed, named, etc. When it has become familiar, all the association fibers that were developed in getting acquainted with the object become aroused at the sight of the object. In the same way each familiar feature of a certain room tends to arouse a group of fibers in the cortex.

When the environment is one that is continuously changing, the changes are simulated in the brain centers, so that we have a mimetic process of the changing situation. We can also have an image process of a former changing environment. In such a case it will be found that the degree of verity is a matter of training and experience. When you hear words spoken in your own tongue, you can easily repeat them. If they are in a foreign tongue, you can scarcely do so. An image process of a changing environment that has high degree verity is no doubt the joint operation of mechanisms of

associative memory. It is safe to say that the concept of time is built up of memory associations connected with change and movement.

In this way we are brought to the conclusion that the coördination of mimetic processes so as to create a correspondence with the world as it really is, is due to the development of association nerve mechanisms or habit mechanisms.

When the nerve mechanisms are highly developed, each point in the observed environment is in communication with a particular area in the brain that acts as an annunciator, as it were. Any change in the environment provokes an annunciating process in a certain area of the brain.

Let us now note that when communication is cut off the potential correspondence does not vanish. It gradually but rapidly diminishes, rapidly at first and then more and more slowly. You can recall the environment of a few seconds ago quite clearly, but that of an hour ago is by no means as clear. When a man has an image process of a past environment it is referred to in speech as arousing a memory image. As we have already noted, the image is an incomplete illusion. Let us remember that the image grows fainter and fainter with the lapse of time. In a book of recent date the author argues that the image is dependent upon motor processes. She states: "The basis of a train of mental images . . . must be the excitation of a train of motor responses."[1] There is much to be said in support of this hypothesis.

The memory image process accompanies the operation of association mechanisms. From our point of view it is the partial resurrection of a former mimetic process. A series of memory images is in many cases a resurrection of a series of mimetic processes in a former experience. There is a tendency for image processes to succeed each other in the same order as the experiences to which they correspond.

It is an interesting question whether the image process can be said to cause effective motor impulses in some cases. It is not quite safe, from our point of view, to say that it can.

[1] Washburn, M. F., 'Movement and Mental Imagery,' Houghton Mifflin Co., Boston & New York, 1916, p. 49.

It may well be that the image process is of no greater direct utility than a rainbow, an echo or the wake of a steamer. We believe, however, that a certain image process may always be followed by a certain movement and it is all the business of association mechanisms. Let us take a sort of middle course and say that the image process in some cases takes part in provoking movement. On the other hand, it is very probable that kinæsthetic impulses from movements or incipient movements take an important part in arousing image processes.

It goes without saying that association mechanisms determine the selection of image processes. The provoking impulses tend to follow those nerve paths that have been left open by recent or frequent previous impulses. In other words the selection of image processes is a matter of habit.[1]

A child's thoughts probably run on the things he has been doing with and the things he has been talking about. As he observes one thing at a time, so does he recall one thing at a time. As he talks about different things in order, so does he recall different things in order and thus confusion of image processes is usually avoided. Of course an image process of yesterday's scene will tend to crowd out one of day before yesterday.

Owing to the great number of association paths, each image process helps to provoke others and so they occur in turn without cessation like a continuous show, except when some interruption produces a mimetic process.

Up to this point we have considered the image process as in correspondence with a past environment. It is true of course that an image process often shows a close correspondence with an environment that transpires later on. We may explain this briefly by saying that a man knows the future by the past, so the image process that anticipates the event is composed of elements derived from earlier mimetic processes. Language habits and education are important factors in such cases. Children can be taught to make new designs and to invent combinations of objects. In a previous article

[1] Angell, *op. cit.*, p. 207.

the writer has shown that purposive behavior can be explained in terms of mechanisms of associative memory.[1] Expectation in image processes can be explained in the same terms, for the same reasons, it is thought.

Let us now take a brief review of our demonstrations. In the beginning we found that a unit feature of the near zone of the environment in active communication with a certain brain area causes a unit nerve change which in effect simulates the feature. The typical mimetic process is constituted in part of such unit nerve changes and in part of changes in association nerve fibers developed by former experience. The nerve fibers used in language and expression play an important part in the mimetic process. The image process is constituted of nerve changes which are the offspring of those in the mimetic process which it simulates. We found that the association mechanisms used in language and expression are important factors in perception. We found that it is largely by association mechanisms that the present environment is simulated in the brain and that the selection of image processes is due to association mechanisms. It follows that the continuity of consciousness is also due to such mechanisms.

In conclusion we may assert that a man's consciousness relates primarily to his environment and depends upon mechanisms for communication and mechanisms of correspondence. The latter are mimetic processes and image processes which are the action of complex nerve mechanisms composed largely of mechanisms of associative memory. The writer has elsewhere demonstrated that associative memory can be explained by the dual common path theory.[2] We need not consider the theory here, but we note that association nerve fibers form paths of varying conductivity for the propagation of nervous impulses.[3] It follows that mimetic processes and image processes are coördinated movements of impulses in connected association nerve fibers in communication, in the

[1] PSYCHOL. REV., 1917, **24**, p. 413.

[2] PSYCHOL. REV., 1916, **23**, p. 235.

[3] The conductivity varies in proportion to the frequency and recency of previous passages.

first instance, with the environment. Just as the blood rushes into a boy's cheeks when he is embarrassed, so do the nervous impulses rush into certain areas of branching nerve paths in the cerebral cortex at the proper signal from the environment. The degree of verity depends upon the extent the association fibers have been developed by previous nervous discharges and upon the number of association fibers that are aroused. These brain processes are of course directly or indirectly provoked by afferent impulses from the organs of sense and often occur in conjunction with effective motor impulses. A conscious voluntary movement is due to effective impulses from the cortex to the muscles in coördination with a mimetic process provoked by the environment.

On consideration we find that when consciousness is most complete there is a brain process having a high degree of verity and composed of coördinated movements of impulses in groups of association nerve fibers. There is adequate communication from the object to the brain and accurate correspondence of the brain process with the object.

On the whole it appears that the developing brain is a highly multiplicate piece of machinery which in its daily period of activity is continually matching itself with some part of the grand total of its past and present environment with a fidelity that increases from time to time.

THE HETEROCHROMATIC DIFFERENTIAL THRESHOLD FOR BRIGHTNESS: THEORETICAL[1]

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VI. Discussion of Results: *B.* The Heterochromatic Brightness Threshold in Relation to Psychological Color Systems

The Bearing of the Results on the Doctrine of Psychological Primary Colors.—The four standards used in the work described in the first installment of the present paper were selected purposely so as to coincide approximately with the spectral positions of the four so-called *psychological primaries*, which form the basis of the Hering, Ladd-Franklin, and other theories of color vision. The direct determinations of the wave-lengths for these primaries made by Westphal,[2] were utilized, although it was necessary to employ simple spectral red in place of spectral red mixed with a slight amount of blue, as demanded by Westphal's results.

It is the opinion of the writer that the specification of these four colors as primaries is not arbitrary, as is claimed by Von Kries, Wundt and others; and can be given a logical justification on the grounds of an analysis of the relations of similarity and difference existing between the members of the hue series. Such analysis indicates that the psychological primaries occupy positions at which critical changes occur in the mode of variation of hue with respect to wave-length, or with respect to hue scale number. In other words, at these points something takes place which is equivalent either to a change of sign of a differential of quality, or to a sudden shift in the qualitative units in which this differential, or derivative, must be expressed.

[1] From the Nela Research Laboratory of the General Electric Co., Cleveland, Ohio.

[2] Westphal, H., 'Unmittelbare Bestimmungen der Urfarben,' *Zeitschrift für Sinnesphysiologie*, 1910, **44**, 182–230.

If, as the Hering theory demands, all possible hues in trichromatic vision are to be regarded as results of the *fusion in various proportions* of non-antagonistic pairs, selected from four primary chromatic qualities, the question of color difference or similarity divides itself into a study (1) of the differences between the primaries, as such, and (2) of the degree of coparticipation of any primary or primaries in a given pair of colors. The distance which separates any two colors on the hue scale would thus be but one of a number of factors determining the actual dissimilarity of the colors in question, as it would be proportional to this dissimilarity only within the range between two neighboring psychological primaries.

TABLE VII

VALUES OF THE THRESHOLD, t, AND ITS VARIATION, v, FOR ALL PAIRS OF PSYCHOLOGICAL PRIMARIES, WITH CORRECTIONS FOR 'SPACE ERROR'

Color Pair	Subject T.		Subject L.	
	t	v	t	v
BG	.126	.056	.134	.062
GB	.159	.032	.072	.019
Mean	.143	.044	.103	.041
Error	.016	.012	.031	.022
BY	.118	.030	.141	.030
YB	.201	.042	.147	.060
Mean	.160	.036	.144	.045
Error	.042	.006	.003	.015
BR	.173	.039	.164	.059
RB	.195	.062	.199	.028
Mean	.184	.051	.182	.044
Error	.011	.012	.018	.017
GY	.173	.044	.103	.033
YG	.185	.041	.148	.030
Mean	.179	.043	.126	.032
Error	.006	.002	.023	.002
GR	.192	.044	.231	.037
RG	.214	.040	.144	.026
Mean	.203	.042	.188	.032
Error	.011	.002	.044	.006
YR	.150	.038	.199	.066
RY	.194	.052	.135	.032
Mean	.172	.045	.167	.049
Error	.022	.007	.032	.017

Table VII. gives the values of the thresholds for all pairs of primaries, each as a standard and as a comparison color. 'Space errors' (see above) and the values of the thresholds, as corrected for these 'errors,' are also given. The corrected

thresholds for both subjects are arranged in order of magnitude in Table VIII., together with the corresponding variation measures. The same table also gives the sizes of the intervals between the primary pairs in the hue scale, in order of magnitude.

It will be noticed that a fairly close correspondence exists between the order of the hue intervals and that of the thresholds, for both subjects, although there is very little

TABLE VIII

CORRECTED VALUES OF THE THRESHOLDS AND VARIATIONS, FOR PAIRS OF PRIMARY COLORS, FOR BOTH SUBJECTS, ARRANGED IN ORDER OF MAGNITUDE; TOGETHER WITH HUE SCALE INTERVALS OF THE SAME PAIRS, SIMILARLY ARRANGED

Subject *T.*		Subject *L.*		Hue Scale Intervals
t	*v*	*t*	*v*	
BG, .143	BY, .036	BG, .103	GY, .032	BG, .175
BY, .160	GR, .042	GY, .126	GR, .032	GY, .255
YR, .172	GY, .043	BY, .144	BG, .041	YR, .325
GY, .179	BG, .044	YR, .167	BR, .044	BY, .430
BR, .184	YR, .045	BR, .182	BY, .045	GR, .580
GR, .203	BR, .051	GR, .188	YR, .049	BR, .755

correspondence in the case of the variation measures. However, that linear separation of qualities in the hue scale cannot be taken as an adequate measure of color difference is obvious at once from the cyclical relation of the hues. Red and violet, for example, resemble each other more closely than do red and green, yet the former pair of colors has a separation on the hue scale of 1.00 whereas the latter has only 0.59. Taking into consideration the cyclical relation of the hues, it can be seen that the only order which the hue scale differences definitely demand of the threshold values in Table VIII. is: BG, GY, YR, $\frac{\text{GR}}{\text{BY}}$. The only significant exception from this order for either subject is in the case of BY. The reversal of GY and YR for subject T (GY, .179; YR, .172) is readily attributable to chance variation.

The average value of the threshold between all psychological primaries is .1733 for subject T. and .1515 for subject L. The average values of the *homochromatic* thresholds for the

two subjects are .0478 and .0403, respectively, the corresponding average heterochromatic comparison factors being 3.626 and 3.760. The average of variation measures, v, for the primary pairs is .0478 for subject T. and .0402 for subject L.; for the homochromatic pairs: .0115, and .0103 respectively; the corresponding factors being 3.766 and 3.902.

It is conceivable that the heterochromatic threshold or comparison factor will provide us with a measure of the actual magnitude of the color difference (or similarity) between two visual qualities, and it is possible that in this capacity they may throw some light not only on the nature of differences due to different degrees of participation of a common primary or primaries in two qualities, but also upon the relations of difference and similarity which must be supposed to hold between the primaries themselves. Although red and green are antagonistic, it is not immediately obvious that red is more dissimilar to green than it is to blue, although introspection seems to confirm the opinion that red and yellow and blue and green form pairs, the members of which possess bonds of resemblance.

Examination of Fig. 7 shows that the exact position of the maximum of the heterochromatic factor, plotted with respect to the color difference between the standard and comparison fields, is not entirely unambiguous. In the case of the red standard the most probable position of the maximum appears to be in the blue-green, which is the complementary of the standard, but in the case of the yellow standard, the maximum seems to be in the green, rather than in the blue. Since the complementary of green is purple, we should not expect to find the maximum for this standard represented in our data; and the drop in the violet, for the green, is probably due to adventitious dioptric influences.

The contents of Table VIII. suggest partial answers to some of the questions raised above. In order to study them more in detail, the average values of the heterochromatic comparison factor were computed for the following cases: (1) for all 'antagonistic' pairs of primary qualities, (2) for all 'neighboring' pairs of primary qualities, (3) for all qualities

in which the psychological primary hue of the standard does not participate, (4) for 'homothermal' pairs (YR, BG), and (5) for 'heterothermal' pairs (BY, GY, BR, GR). The results are shown in Table IX., first, including the data from the blue standard and, second, omitting these data on account of their doubtful significance. It will be seen from the table that

TABLE IX

THE HETEROCHROMATIC FACTOR AVERAGED FOR DIFFERENT CLASSES OF QUALITIES (SEE TEXT)

Class of Qualities	Including Blue			Excluding Blue		
	Subject T.	Subject L.	Mean	Subject T.	Subject L.	Mean
Antagonistic pairs of primaries...	3.60	5.10	4.35	5.27	6.04	5.66
Neighboring pairs of primaries...	3.93	4.01	3.97	4.57	4.54	4.56
Non-coparticipating pairs.....	3.77	4.41	4.09	4.60	5.38	4.99
Homothermal pairs of primaries..	3.68	3.82	3.75	4.35	4.37	4.36
Heterothermal pairs of primaries..	4.39	4.66	4.52	5.04	5.38	5.21

the average value of f is considerably lower for the neighboring pairs than it is for the antagonistic pairs, the difference being still more marked if the data from the blue standard are neglected. The ratio between the two is 0.913 with the data from the blue standard, and 0.806 without these data. The average value of f for the third case mentioned above, lies between those for the first two cases. This would seem to indicate that antagonistic primaries differ intrinsically more than do non-antagonistic primaries. However, the difference between the average heterochromatic factor for the two cases is not large, and is perhaps increased illegitimately by the fact that the red standard—being a spectral red—contained a slight yellowish component.

The grouping of the primary hues into 'warm' and 'cold' pairs, on the basis of direct inspection, appears also to be supported by the results shown in Table IX., since the average value of the heterochromatic factor for all homothermal pairs is 3.75 (or 4.36) as compared with 4.52 (or 5.21) for all heterothermal pairs.

In considering these results it should be borne in mind, not only that the use of the heterochromatic factor as an

index of absolute color difference is hypothetical, but that the subjective or experienced color quality of the standard cannot be regarded as being strictly constant in our experiments, on account of the influence of *color contrast.* Such contrast would tend to move the hue of the standard along the hue scale in a direction opposite to that taken by the variation of the comparison color. At present, there are no data available which can be used to correct for, or to evaluate this effect. In general, it would tend to make the actual hue differences greater than those represented in Fig. 7, and would compel us to regard the position chosen for the standard in the hue scale as being merely its approximate mean position for a complete set of comparisons around the color cycle. In the present work, since the comparison sets omit the purples, the mean positions will be displaced—except possibly in the case of the green standard—towards the end of the spectrum to which the given standard is in closest proximity.

The Theory of the Influence of Color Difference on the Brightness Threshold.—In a previous paper[1] the writer has suggested, as a general principle, the statement that 'the distinctness of any experiential (or qualitative) dimension changes in parallel with the degree of similarity of two compared experiences in all other dimensions.' For example, if we consider the quality of any visual sensation as being determined by its position in an ideal three-dimensional scale, having the coördinates, hue, saturation, and luminosity, the magnitude of the just noticeable difference in hue would possess a minimum for equal luminosities of compared sensations; or, *vice versa,* the just noticeable difference in luminosity would have a minimum—as shown in our experiments—for identical hue values.

If we represent these dimensions geometrically, it can easily be seen that an analogous relationship exists in the case of the discrimination of spatial positions or levels. Suppose that *a* is a fixed point in a plane, that *b* is a variable position, and that we are required by simple observation to determine the positions of *b* at which it appears to be just noticeably

[1] The paper previously cited, J. of Exp. Psychol., 1917, 2, 18.

above an imaginary horizontal axis drawn through *a*. It is self-evident that the deviation of these positions from the true horizontal will be greater the greater the separation of *a* from *b* along the axis in question. The position of this locus of thresholds will be determined by at least two factors: (1) the space threshold, or visual acuity, which holds when *a* and *b* are on the same vertical, and (2) the certainty with which the 'eye' can establish an imaginal horizontal line with respect to which to estimate the position of *b*.

It would be a reasonable hypothesis to suppose that the mean variation of the position of the imaginal axis is a constant when expressed in *angular* terms, *i. e.*, that the axis acts like an inflexible line swinging about *a* as a fulcrum. If this mean angular variation is ϕ, and if d is the separation of *b* from the vertical axis, the mean linear variation of the position of the axis, in the vertical passing through *b*, must be $d \tan \phi$. If the acuity threshold is u, the magnitude of the threshold for vertical displacement should be in accordance with the accepted theory of 'propagated errors.'

$$v = \sqrt{u^2 + d^2 \tan^2 \phi}. \tag{9}$$

Schemes such as the conventional color triangle or color pyramid, which attempt to give a geometrical representation of a two or three-dimensional scale of experiential qualities, are constructed on the tacit assumption that the relations between the qualitative dimensions are quantitatively the same as those of the axes and units of the space system. Although this is by no means a logical necessity, it may prove of some interest to work out certain elementary consequences of this assumption in its application to the theory of the heterochromatic factor. The natural unit of measurement along all axes of a qualitative system is, of course, the just noticeable difference, or sensory threshold.

The system of visual qualities is represented by Titchener, and others, by means of a double pyramid.[1] The equator of this pyramid encloses a quadrilateral plane figure, the apices of which are the positions of the four psychological primaries.

[1] Titchener, E. B., 'A Text-Book of Psychology,' 1910, 63.

The purpose of this construction is to represent the 'linear' character of the variation in hue occurring in the intervals between primaries, and the sudden alterations in the mode of variation, which appear at the primaries. If the construction is valid, the separation of any two hues in the hue scale must be taken to represent the distance between them, measured along the 'equator' of the pyramid, while their 'true' difference would be given by the length of a straight line joining their positions. Such a straight line would coincide with the 'equator' only when both of the hues in question lay between the same two psychological primaries.

However, very simple considerations show that the representation of the relations of the spectral colors by means of a quadrilateral figure with rectilinear boundaries, cannot be accepted as mathematically correct. Such a diagram requires that the primaries should have a greater degree of saturation than have intermediate hues. Even if this were the case for the hues as given in the spectrum, it would be impossible to accept the relationship as a condition of the differentiation of the hues in general, since all of the hues may conceivably exist in equal saturation, without losing their distinctive character. However, the requirement is not even satisfied by the spectral colors, since—as shown by the laws of color mixture and color flicker—the saturation of these colors increases continuously from the middle of the spectrum towards either extreme. In the light of these considerations it must be deemed necessary to replace the quadrilateral by a figure with curving boundaries. The exact form of this figure for the spectral colors has not been determined, although it is probably somewhat similar to the ordinary color-triangle plot of the spectral hues.

If the figure in question were a circle—as it would be for a series of equally saturated colors—the value of the 'true' difference, d, between any two colors (see equation 9) in terms of the hue scale difference, h, would be

$$d = 2\,s \sin(h/2s), \tag{10}$$

where s is the radius of the circle—or the saturation of the

colors represented upon it—and the angle is expressed in radians. This is the usual formula for a chord of a circle. When combined with equation (9) this gives, for the heterochromatic factor,

$$f = \sqrt{1 - k \sin^2\left(\frac{h}{2s}\right)}, \tag{11}$$

If $h = 0$ or $2\pi s$, $f = 1$; if $h = \pi s$, $f = \sqrt{1 - k}$, which is its maximum value. The latter relationship permits us to write

$$k = f_{max}^2 - 1, \tag{12}$$

so that if we take $f_{max} = 5$, $k = 24$. The resulting curve is plotted in Fig. 8. This will be seen to satisfy the typical set

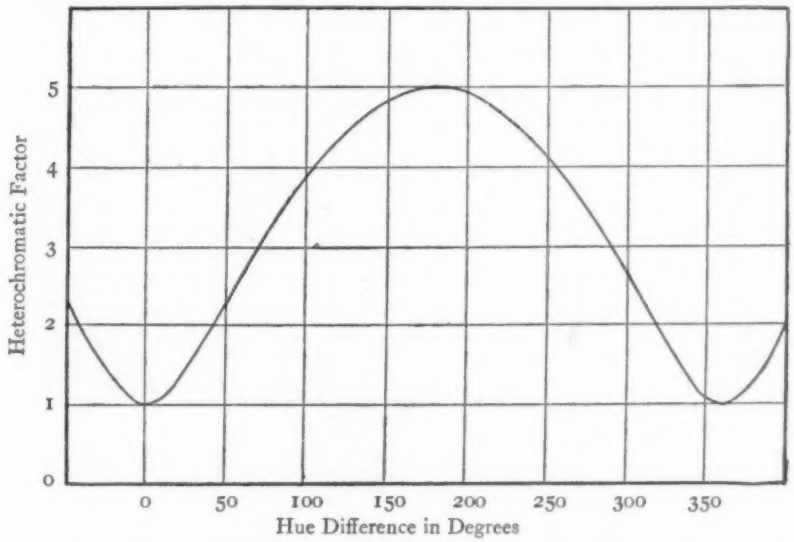

FIG. 8. Theoretical relationship between the heterochromatic factor and hue difference.

of data as regards general form. However, even if the geometrical analogies are all valid, complete agreement should not be expected, since our data are for spectral, rather than for equally saturated colors.

It will be noted that the above argument virtually em-

[1] The writer acknowledges his indebtedness to Dr. P. W. Cobb for his suggestive criticisms of this theory.

ploys an angular scale of hues, with a unit equal to $H/2\pi$ threshold units, where H is the total number of threshold differences in the color circle. Absolute hue is thus made a sort of trigonometrical or periodic function of hue difference, so that the hue for $h = 2\pi$ is the same as that for $h = 0$, and so on, assuming an axis of coördinates through any fixed point in the circle.[1] This use of circular notation to symbolize the relations of the hues appears to be more in harmony with the facts in the case than does the employment of linear symbolism. At present, however, it is an open question whether the relation, $H = 2\pi s$, which is implied by the spatial color diagram, actually holds for a cycle of equally saturated colors, when H and s are both measured by the threshold method.

The general theory of the elevation of the luminosity threshold with increase in the color difference between the compared fields, above suggested, is obviously consistent with the statement that the qualitative dimensions of luminosity and hue are to a certain extent *indeterminate*, since the axes with respect to which definite luminosities and hues are measured are not rigidly fixed in the system, but oscillate about a mean position. This mean variation in the angular position of the axes represents diagrammatically our uncertainty whether we are making a luminosity comparison, a hue comparison, or a comparison of saturations. It is only when the actual luminosity difference exceeds, by a just noticeable difference, the variability of the coördinates, that a definite judgment can be made. The origin of coördinates in such comparisons, is taken through one of the compared qualities.

As the writer has previously pointed out, this conception, if valid, has an immediate application to the controversy concerning the relative merits of the 'direct comparison' and 'flicker' photometers. In the flicker photometer, color difference is eliminated by fusion, so that the judgment is between successive qualities having the same color, but dif-

[1] I find that criticisms and suggestions, with regard to the dimensions of the color solid, very similar to the above, have been made by H. C. Warren, in a paper presented to the American Psychological Association in 1909, and abstracted in the Proceedings of the Association, PSYCHOL. BULL., 1910, 7, 51–52.

ferent luminosities. In 'direct' or simultaneous comparison, the dimension of luminosity (as a concept) becomes inherently unstable. Moreover, different observers—as experience has shown—will establish their coördinates for the discrimination of luminosities, in different 'directions' in the color scale, some with a tilt towards the blue or towards white, others with a tilt towards the red. The present writer, for example, tends to overestimate yellow in comparison with other colors, apparently because yellowishness is to a certain extent involved in his concept of luminosity.

This uncertainty in the definition of luminosity, in the presence of a color difference, is expressed very well by Helmholtz, who says:[1] "I scarcely trust my judgment upon the equivalence of the heterochromatic brightnesses, at any rate upon greater and smaller in extreme cases. I admit, however, that one can gradually so darken one of two colored fields that no doubt remains as to the other being now the brighter . . . . As far as my own senses are concerned I have the impression that in heterochromatic luminosity equations it is not a question of the comparison of one magnitude, but of the combination of two, brightness and color-glow (*Farbengluth*), for which I do not know how to form any simple sum, and which too I cannot further define in scientific terms."

The above suggestions concerning the theory of heterochromatic differential threshold for brightness are of course very tentative, and should be supplemented by an hypothesis stated in physiological terms. Unfortunately, however, our knowledge of the physico-chemical processes which underlie discrimination, regarded as a nervous function, is practically nil. Before these problems can be attacked, we must at least possess a tenable theory of the manner of conduction of intensity and quality to the centers, a problem which at present remains unsolved.

[1] Helmholtz, H. von, 'Handbuch der physiologischen Optik,' IIte Auflage, 1896, 440. The translation is that given by J. H. Parsons, in his 'Introduction to the Study of Color Vision,' 1915, 43.

VII. Discussion of Results: *C.* The Relation between the Threshold and its Variation Measure

The properties of the variation measures, v, of the measurements reported above are of both theoretical and practical interest. These measures are given in Tables III. and IV., and are plotted in Figs. 3 to 8, inclusive.

Relative Precisions of the Threshold 'Points.'—In order to ascertain the relative precisions with which the several 'points' determining the threshold can be found, the fractional mean variations of each of the four points were averaged for all colors compared with each standard. The results are given in Table X. It will be perceived that, in the general average for all standards and all comparison colors, both subjects exhibit the same order in the arrangement of the points according to precision, viz., *a*, *b*, *c*, *d* (see page 318 above). From the values shown in Table X., it appears that, at least

Table X

Average Relative Precision of the Determining 'Points' of the Threshold (Fractional Mean Variation) for Two Subjects, and All Measurements Taken at 25 Photons

Case	Subject T.	Subject L.	Av. T. and L.
a (j. n. brighter)	.0341	.0233	.0267
b (j. n. n. brighter)	.0377	.0303	.0340
c (j. n. darker)	.0391	.0367	.0379
d (j. n. n. darker)	.0385	.0314	.0350
Av. of *a* and *c* (j. n. d.)	.0366	.0300	.0333
Av. of *b* and *d* (j. n. n. d.)	.0381	.0309	.0345
Av. of *a* and *d* (increase)	.0363	.0274	.0319
Av. of *b* and *c* (decrease)	.0384	.0335	.0360
Av. of *a* and *b* (brighter)	.0359	.0268	.0314
Av. of *c* and *d* (darker)	.0388	.0341	.0365

under the conditions of experimentation here described, an *increase* in the brightness of a variable field compared with a constant is more readily detected than a decrease; but that a judgment of equality (just not noticeably different) has nearly the same accuracy as a judgment of difference (just noticeably different). There is, however, a slight tendency in favor of the difference judgment. 'Just noticeably brighter' is the most accurate judgment of all; 'just noticeably darker'

the least accurate. The order of accuracy is represented conveniently by the numbers in the following diagram $\begin{matrix} b2 \\ c4 \end{matrix} \Big\downarrow\Big\uparrow \begin{matrix} 1a \\ 3d \end{matrix}$ the direction of the arrows indicating the direction of change of the variable brightness as the judgment was being made.

The Correlation between v and t.—It is obvious from Tables III. and IV. that v tends to increase as t increases, and that the relation between them is roughly linear. In order to throw more light upon this relationship, each value of t was divided by the corresponding value of v. The resulting quotients are given in Table XI. The genera[1] average of t/v for sub-

TABLE XI

VALUES OF THE RATIO, t/v (SEE TEXT), FOR TWO SUBJECTS, T. AND L., FOUR STANDARD COLORS, AND THIRTEEN COMPARISON COLORS, AT 25 PHOTONS

Comparison Color, μμ	Standard Color, μμ			
	Blue, 475	Green, 505	Yellow, 575	Red, 693
430, (T.).....	6.30	4.06	3.66	3.26
(L.).....	3.91	2.55	4.13	2.70
460, (T.).....	3.87	4.18	6.33	4.97
(L.).....	3.42	3.91	3.65	3.65
475, (T.).....	5.58	4.93	4.79	3.14
(L.).....	4.91	2.77	2.47	7.12
490, (T.).....	3.72	4.15	2.75	3.88
(L.).....	6.95	3.33	5.00	3.20
505, (T.).....	2.24	3.88	4.46	4.99
(L.).....	2.16	6.64	4.88	5.47
520, (T.).....	2.82	4.25	4.88	5.08
(L.).....	4.01	2.83	3.40	3.49
550, (T.).....	2.96	4.89	3.54	4.10
(L.).....	5.65	3.38	2.80	2.97
575, (T.).....	3.98	3.96	3.78	3.73
(L.).....	4.73	3.08	3.65	4.27
580, (T.).....	2.47	4.15	4.25	3.49
(L.).....	3.49	4.30	3.97	4.08
610, (T.).....	3.89	4.02	3.58	3.64
(L.).....	5.63	4.04	2.59	4.09
640, (T.).....	3.35	3.76	4.25	3.35
(L.).....	4.02	7.30	2.72	3.51
670, (T.).....	2.94	4.39	5.38	2.94
(L.).....	5.91	8.23	3.29	3.70
693, (T.).....	4.45	4.36	3.92	2.99
(L.).....	2.80	6.28	2.84	2.89

ject T. is 4.012 (m.v. = 0.61), and for subject L, 4.09 (m.v. = 1.04). Assuming the relationship to be linear, this would mean that, approximately, $t = 4v$, or the threshold as found by the method of limits is equal to four times the average

mean variation of its determining points. Diffusion plots of the actual values are given in Figs. 9 and 10.

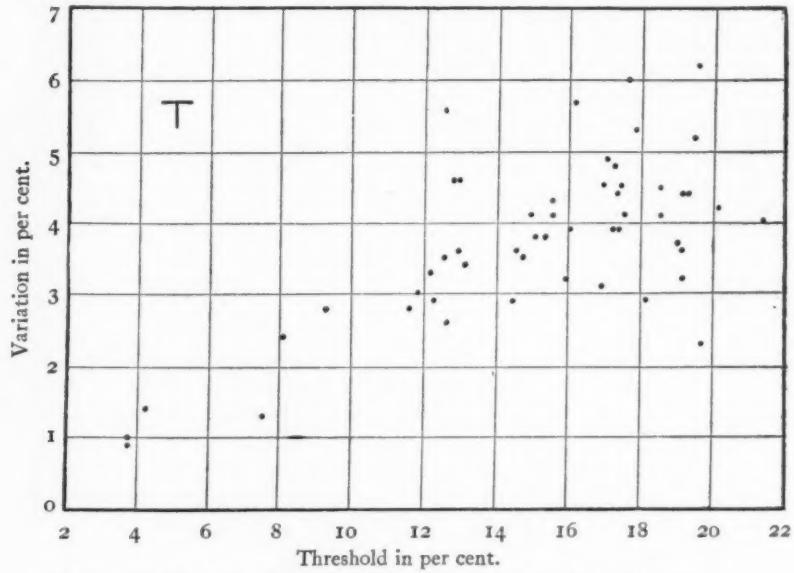

FIG. 9. Diffusion plot of threshold and variation values for subject T.

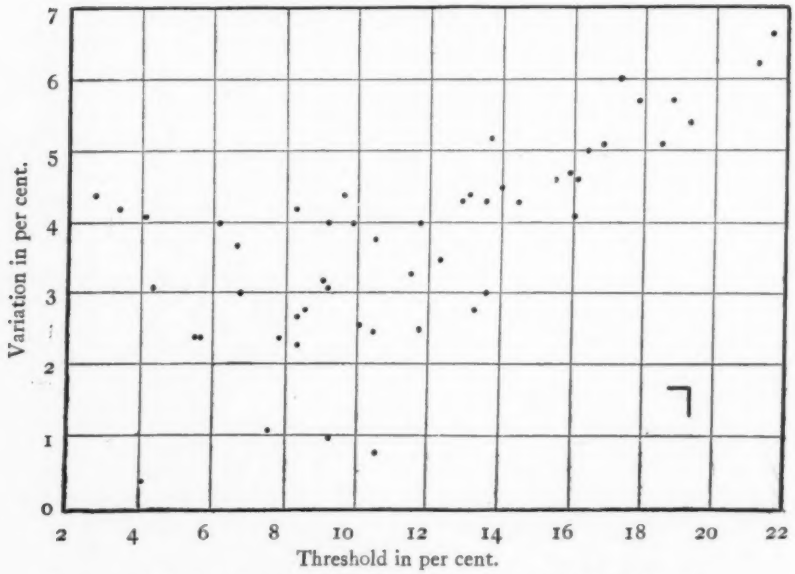

FIG. 10. Diffusion plot of threshold and variation values for subject L.

As a further study of this relationship, coefficients of correlation between t and t/v, were calculated by the conventional 'product-moments' formula. The results are given in Table XII. It will be perceived that for subject T. the

TABLE XII

CORRELATION RATIOS, r, BETWEEN t AND t/v, FOR FOUR STANDARD COLORS, AND TWO SUBJECTS, T. AND L.

Standard Color, $\mu\mu$	Correlation Ratio, r		P. E. of r	
	Subject T.	Subject L.	Subject T.	Subject L.
Blue, 475	− .0212	− .104	.187	.185
Green, 505	+ .281	+ .693	.172	.097
Yellow, 575	+ .341	+ .0850	.165	.187
Red, 693	+ .588	+ .526	.122	.135
Algebraic sum	+1.188	+1.200		
Algebraic average	+ .297	+ .300		

correlation is positive, and large, in the red, and decreases in passing along the spectrum in such a manner as to assume a slight negative value in the blue. The average value of the coefficient, .297, indicates that, in general, t/v tends to increase with increase in t,[1] so that the curve representing the actual function connecting t and v must be somewhat concave with respect to the axis of t, being represented approximately by the formula, $t = k\, v^q$ where $q > 1$. However, q decreases as we pass from the red to the blue end of the spectrum, and becomes less than unity in the blue.

The correlation values for subject L exhibit a tendency similar to those shown by the values for subject T, although less clear cut. The average value for L is .300, practically the same as that for T.

Mean Variation of the Threshold Values.—The mean variation of the determining points of the threshold is of course to be distinguished from that of the threshold itself. The latter can be calculated from the former, by means of the theory of propagated errors, application of which to the pro-

[1] If $y = f(x)$, $y/f(x) = 1$, and the correlation between a variable and a constant, such as unity, is zero. Hence, if we divide each value of y by $f(x)$, using the corresponding x, the coefficient of correlation between y and $y/f(x)$ should not differ significantly from zero, if we have chosen the right function.

blem gives the following formula[1] for the numerical mean variation, Δt, of the threshold in terms of the numerical mean variations, Δi and Δj, of the quantities, i and j in equation (5):

$$\Delta t = \tfrac{1}{2}\sqrt{\frac{1}{ij}\left[\left(\frac{j}{i}\Delta i\right)^2 + (\Delta j)^2\right]}. \tag{13}$$

For the purpose of our present calculations the difference in magnitude between $\Delta i/i$ and $\Delta j/j$ may be neglected, so that each of these quantities may be set equal to u. This permits us to rewrite (13)

$$\Delta t = \frac{u}{2}\sqrt{2j/i}. \tag{14}$$

But, from the definition of the threshold, $h/i = j/h = 1 - t$, where $h = \sqrt{ij}$ is a constant; so that $j = h(1 - t)$ and $i = h/(1 - t)$, whence:

$$\Delta t = \frac{1 - t}{\sqrt{2}}u. \tag{15}$$

In our calculations, i and j are the geometrical means of pairs of values contained in the formulæ: $i = \sqrt{ab}$, and $j = \sqrt{cd}$. By the theory of propagated errors:

$$\Delta i = \tfrac{1}{2}\sqrt{\frac{1}{ab}[(b\,\Delta a)^2 + (a\,\Delta b)^2]}, \tag{16}$$

but if $\Delta a/a = \Delta b/b = v$, we have, from (16)

$$\Delta i = \frac{v}{\sqrt{2}}\sqrt{ab}, \tag{17}$$

or $\Delta i/i = v/\sqrt{2} = u$. Hence we have for the numerical mean variation of the (fractional) threshold, as determined by the method of limits (using four points):

$$\Delta t = \frac{1}{\sqrt{n}}\,\frac{1 - t}{2}v, \tag{18}$$

where n is the number of measurements made on each of the four points, assuming the same number to have been made on

[1] This relationship was developed by differentiating the expression, $t = (i - \sqrt{ij})/i$, with respect to i and with respect to j, separately; multiplying each derivative by the corresponding m.v. and taking the square root of the sum of the squares of these products. This gives the most probable value of the m.v. of t.

each, and v is the average fractional mean variation of the individual determinations in each of the sets.

The data tabulated above show that, on the average, $v = t/4$, and that the deviation from this proportionality, for different heterochromatic comparisons, as tested by correlation ratios, is not great. Substituting this value of v in (18), we have:

$$\Delta t = \frac{1}{8\sqrt{n}} t(1 - t), \tag{19}$$

or, for the fractional variation,

$$\Delta t/t = \frac{1}{8\sqrt{n}} (1 - t). \tag{20}$$

For subject T., $n = 10$ (or more); for subject L., $n = 5$; so that the average fractional variation of the threshold for T. would be 0.040 $(1 - t)$, and for L., 0.056 $(1 - t)$. The largest value of t, for subject T. is .214, for which $\Delta t/t = .031$; the corresponding value for L. being .043. In other words, the mean variations of the average threshold values given in Table III. are in the neighborhood of three or four per cent.

In connection with this discussion it is of interest to consider the precision with which the value of $h = \sqrt{ij}$ can be determined, *i. e.*, the accuracy obtainable in heterochromatic photometry by direct comparison, when instead of attempting to equate two luminosities, we determine the upper and lower points for threshold difference between the standard and measured brightnesses.

By analogy with equation (17):

$$\Delta h/h = u/\sqrt{2}, \tag{21}$$

where u is the fractional mean variation of i and j. But $u = v/\sqrt{2}$, and $v = t/4$, so that

$$\Delta h/h = t/8 = .125t, \tag{22}$$

when one determination is made of each of the four points.

It would be interesting to compare this result with the precision obtainable by the method of random setting to apparent equality, using the same number of determinations.

This comparison could be carried out by the use of data obtained by the method in question under conditions similar to those of the above experiments, or in terms of calculated values based upon the data already at hand. Considerations of space forbid discussion of this problem in the present paper, but the writer hopes in a later article to treat this and allied questions concerning the statistics and precision of photometric measurements, in detail.

VIII. Summary

The purpose of the measurements discussed in the present paper was to determine the differential threshold for brightness as a function of the color difference existing between the compared photometric fields.

Values of the relative threshold with their variation measures were obtained for two subjects, using four standard spectral colors—the psychological primaries—and thirteen comparison colors—distributed over the entire spectrum—at an intensity of 25 photons. A supplementary series using one standard was carried out, for one subject, at an intensity of 240 photons. The 'method of limits' was employed.

Values of the 'heterochromatic comparison factor' or the ratio between the heterochromatic and the corresponding homochromatic thresholds, are calculated for all of the measurements made at 25 photons. This factor varies from unity, for no color difference, to a maximum of five to ten, for a maximum of color difference. The function connecting the heterochromatic factor with the color difference, expressed in just noticeable hue steps, represents approximately a segment of an ellipse.

In considering the bearing of the results upon the doctrine of psychological primary colors, it is found that, on the average, the value of the heterochromatic factor is greater for pairs of 'antagonistic' colors than for non-antagonistic pairs, and greater for pairs of 'warm' with 'cold' colors than for 'warm' with 'warm,' or 'cold' with 'cold.' Other interesting groups are studied in a similar way.

A discussion of the results in their relation to the 'color

pyramid' is presented, together with a general psychological theory to explain the influence of color difference upon luminosity discrimination.

Special attention is given to the variation measures of the four 'points' determining the threshold values. The relation between the average mean variation of these four points and the corresponding threshold value is found to be approximately a proportionality, the variation being approximately one quarter of the threshold. The deviations of this relationship from proportionality are studied, for the various standards, by means of correlation ratios.

The probable mean variations of the final threshold results are also calculated and shown to lie between three and four per cent.

ASSOCIATIVE AIDS: III. THEIR RELATION TO THE THEORY OF THOUGHT AND TO METHODOLOGY IN PSYCHOLOGY[1]

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V

We may consider the learning of associated pairs under yet another aspect, namely as problems to be solved by thought. That these are simple, but nevertheless real problems, is evidenced by the following facts: Most of them required more than one prompting, many of the responses were misplaced, sometimes responses of the subject's own construction were supplied, in the first few days the responses were slow and uncertain, and many of them were connected with their proper stimuli by ingenious associations of the subject's own device. That is, the learning of a pair involved an analytic function in that the pairs had to be separated from each other and a synthetic function in that two particular words or syllables, and no other, had to be connected.

The problematic character of the learning of these pairs is well illustrated by Mr. Teh's learning of 'yab lek.' On the first day he responded with 'zum' in 3″. Somehow it seemed right to him, although it is an entirely new syllable. The second and third times he responded with 'rem' in 2.4″ and 13.6″. This is also a new syllable. He knew it was wrong when he repeated it but could not think of any other syllable that had an *e* in it. Then he found the association that the correct response begins with the letter before *m* and responded correctly the next time in 3.4″. On the second day this association had slipped away. 'Yab' suggested nothing the first time. The second time he thought of 'rem' again but he did not speak it because he knew it was wrong.

[1] The background for this paper is furnished by my two previous papers on Associative Aids.

The reaction times were 4.6″ and 10.6″ respectively. His old association now came back and the next time he responded correctly in 3.4″. On the fourth day, it failed to suggest 'lek' in 8″, but the second time the response was immediate, .8″. He responded correctly on the fifth and sixth days in 1.4 and 2.3″ respectively. The old association had dropped away, but 'rem' still kept popping into his mind.

In this case, the subject had to distinguish 'lek' from 'zum' and 'rem.' The latter was suggested by the thought that the correct response has an *e* in it, and this error was made a connecting link with 'lek' by the thought that the proper response begins with the letter before *m*. The thought of 'rem' was therefore the occasion not only for an analysis in that it had to be separated from the correct response but also the occasion for a synthesis of the correct response with its stimulus by means of a peculiar association. Although the thinking here is far from being syllogistic or logical it is nevertheless real and effective psychologically, and has the essential characteristics of thinking, namely, separating out and combining certain ideas in order to reach a desired end. The example given above involves more thinking than does learning a pair without association. In the latter, however, the response must be at least distinguished from nine others, and connected with a particular stimulus, although without any intermediate links. So long as this response must be made consciously and with attention, we should not hesitate to call it thinking, but with continued repetition the response becomes gradually unconscious and is made without attention. That is, it becomes a type of reflex action. Where this point is reached, there is no thinking in the psychological sense of the word, it is simply habit. This gives rise to the questions, What stage of the problem-solving process shall we call thinking? And what are the important characteristics of that stage? Before answering these questions, let us consider the influence of practice upon thinking (*a*) as it is expressed in association, and (*b*) as it is expressed in sensory content.

The effect of practice upon the course of association we have described in the previous paper. We noticed that they have a high frequency only during the early stages of learning. They are gradually eliminated through practice and do not occur at all in a mechanical response.

The effect of practice upon the conscious content of thinking was not within the purpose of our experiment since we asked our subjects to report only *what* they thought about between the stimulus and the response. A few of them, however, said that they saw such and such objects or printed words in their minds. The effect of practice upon these images was the same as that upon associative aids, *i. e.*, they appeared during the problematic stage of thinking and disappeared when the response became mechanical. If we examine the literature upon this matter, we find ample confirmation of this view. The experimental investigations of habit-formation and of the nature of thinking are studies in point.

The appearance of imagery and sensational elements in habit-formation was made an object of study by Book,[1] Rowe,[2] Angell and Coover[3] and others. Their studies are particularly valuable because their investigations were not based either for or against a sensational theory of thought. The following observations of sensory and imaginal factors in the development of voluntary control were made by Book, who studied the learning of typewriting: The subjects who learned by the touch method first learned the keyboard. One subject learned it so well that he could reproduce a map of it from memory. The keyboard was then screened and the process of writing began. In this the subject first got the copy; second, pronounced the letter; third, located it mentally on the keyboard, *e. g.*, formed a visual image of its position; fourth, got the finger on the proper key by first locating its row and then counting and feeling the individual keys until the proper one was found; and fifth, pronounced the letter again and made the proper movement. During

[1] 'Psychology of Skill,' 1908.
[2] *Amer. J. of Psychol.*, 1910, 21, 513–562.
[3] *Amer. J. of Psychol.*, 1907, 18, 327–340.

the early stages the letter was sometimes forgotten in this complicated process. In the course of improvement there was a gradual elimination of these numerous steps. The initial spelling of the words dropped away and the letters were correctly written by the sight of them. The mental locating of the keys and the complicated finger movements made in order to find the right key dropped away when the subject was able to find the proper key by the 'feel' of the movement necessary to hit it. The 'feel' also faded away when the subject was able to recognize the correctness of a key by the touch. The inner spelling continued the longest of these intermediate processes, but it also dropped away, so that the sight of the copy led directly to the hitting of the proper keys. The inner spelling, however, reappeared whenever difficult words were met.

Rowe, who had four subjects practice, until the reactions became automatic, writing ten standard words by pressing small rubber bulbs arranged so as to correspond in numbers and in letter-order to the lower row of keys in a Blickensderfer typewriter, reports the following about the appearance of imagery:

"It is only when a certain degree of skill and proficiency has been reached that imagery . . . of any sort becomes important. This imagery was uniformly derived from the preceding perceptual experiences in making the movements (voluntarily). . . . Much of the control imagery as such fades away with practice and . . . in the last stages of a voluntary movement a complex idea of the general situation, with little or no *particular* imagery of a clear character, is sufficient to carry on a series of practiced movements. In this stage the sensations arising from the movements themselves do not necessarily give rise to perceptions, but perform their proper functions without the aid of supplementary ideational processes."[1] Angell and Coover, whose experiment was referred to before; Leuba and Hyde[2] who had subjects practice writing English prose into German script; and Bryan and Harter,[3]

[1] *Amer. J. of Psychol.*, 1910, **21**, p. 536.

[2] PSYCHOL. REV., 1905, **12**, 351–369.

[3] PSYCHOL. REV., 1897, **4**, 27–53; 1899, **6**, 345–375.

whose subjects practiced on learning telegraphy, have made similar observations regarding the elimination by practice of sensory, imaginal, and associative processes intermediate between the stimulus and the response. Woodworth,[1] on the other hand, who sought to find the causes of a voluntary movement by having subjects do such highly mechanized acts as winking the eye, wagging the jaw, bending a finger, moving a forefinger to the nose, and opening the mouth, found very little imagery either immediately before the stimulus or between the stimulus and the response, and concludes that not any imagery is a determinant of voluntary movement. Against him are such experiments as those of Downey,[2] who had subjects do handwriting in new and difficult positions, and of Finkenbinder,[3] who had subjects solve difficult arithmetical and other problems, which find the employment of an abundance of imagery in the solution of their problems and, therefore, reach conclusions contrary to Woodworth's. But the explanation undoubtedly is that the experiments of Downey and of Finkenbinder come in the problematic stage of response, while those of Woodworth come in the mechanized stage. From these investigators who have observed the course of sensory and imaginal processes in habit-formations we believe that we may infer that their behavior is the same as that of the associative processes which we have made a special object of study. If we turn to the experimental studies of thinking, we find a number of reasons for taking a similar view as regards not only the sensory and imaginal components of consciousness but also the newly discovered non-sensory elements and forms.

The influence of practice upon sensory or imaginal components in the perception of letters is described by Clarke as follows:

"In the early part of the series, O. reports sensations from the different parts of the body, as the bending of the neck, stamping of the feet on the floor, pressing together of the teeth, and auditory images of the sound made by the finger

[1] 'Causes of Voluntary Movement,' Garman Memorial Volume, 351–392.

[2] PSYCHOL. MONOG., 1908, 9, No. 37.

[3] *Amer. J. of Psychol.*, 1914, 25, 32–81.

in moving over the paper. About the middle of the series he several times remarks: 'I did not notice the bodily adjustment of attention,' and in the last thirty or more experiments the introspection usually begins with the perception of the letter. If there is anything before this, it is usually the auditory sensation from the rubbing of the fingers over the paper. The strained condition of the body is mentioned only once in the last thirty cases. In the reports of F., also, we notice a marked falling-off in the number of conscious contents occurring before the appearance of the stimulus. The first introspection is almost entirely an account of the fore-period, and includes strain, breathing sensations, kinæsthetic, temperature, verbal and visual images, some of these occurring several times. In the experiments immediately following, the contents of this waiting period are only slightly decreased. Later the observer reports: Kinæsthetic and visual images of moving fast over the letter. Later, again: The 'ready' set me off without a conscious *Aufgabe*. The idea of movement with the tactual image is repeated a great many times, but toward the last is described as vague, and does not appear at all in some of the latest observations of the series."

That the *Bewusstheit* of Ach[1] appears only after a response becomes well practiced is indicated by the following observations as reported by him:

C.'s reactions to one of four letters, quadruple coördination:

"C., during the fore-period, had the necessity of repeating the coördinations. This imprinting occurred mostly in the manner that 'hb = right and dk = left' was spoken in inner speech. With this the proper voluntary sensations of the movement of the eyes or hand were imaged. After this had occurred in several experiments, there appeared one or two reactions the preadjustment of which was *unanschaulich*. . . . Afterwards an associative imprinting began again. Corresponding to the imprinting, the perception of the stimulus reproduced the image of the proper arm in the form of *Inten-*

[1] 'Über die Willenstätigkeit und das Denken,' 1905.

tionen, sensations of movement. The movement of the correct finger occurred immediately without any necessity of an image of the individual finger. In most cases the process took place in this way: the presented letter, *e. g.*, d, reproduced the image of d. The proper reaction resulted immediately from this middle term. . . . *Finally* . . . the clear apperception of the letter, which under these circumstances consumed the larger part of the reaction time, *selected after a short period, the proper reaction without the necessity of a middle term.*"[1]

B.'s experience in reacting to the two numbers which he might add, subtract, multiply, or divide:

"During the course of the experiment, B. changed the condition of his 'set.' At first the goal idea appeared as an auditory kinæsthetic image, and about two or three times in succession. Since several premature reactions occurred during the first day and at the beginning of the second day, because of the familiar motor pressure to say 'pe' before the result was given, a precaution was added to the instruction already given, namely, not to react too quickly but above all to complete the reaction. Hence for several experiments the adjustment was prepared by saying, 'Add.' In consequence of the meaning of this operation, there was an optical plus sign in consciousness (in subtraction only a flighty minus sign in one case). This visual scheme disappeared after a few experiments to give place to a spatial adjustment of the attention in this way: the attention sought to embrace not one point but a large part of the shutter, and with this the momentary purpose was present as an awareness" (*Bewusstseinheit*).[2]

Another important concept invented by Ach is that of *Determinierenden Tendenzen.* The ground of this concept is found in such results as the following: When two numbers with a vertical line between them were shown, and the subject had the choice of adding, multiplying, subtracting, or dividing them, he, in the early stages of the experiment, usually in-

[1] *Op. cit.*, 143–144. Italics mine.

[2] *Op. cit.*, p. 175.

structed himself during the foreperiod by repeating his task in inner speech, or he saw images of mathematical signs between the numbers, or added them verbally, *e. g.*, 5 and 2 are 7. But in the later stages the result was immediate upon the appearance of the stimulus. It occurred without these images and without any awareness of what was to be done with the numbers. That is, there was an apperceptive fusion of the result with the stimulus. A similar experience occurred with the naming of alliterative syllables in response to nonsense syllables. Correct responses were made without any awareness of the task. The latter, however, came to consciousness when stimuli appeared that were not in agreement with the instruction.

The difficulty here as with Ach's *Aufgabe* is to explain the making of correct responses without being aware of it. But in the light of our knowledge of habit formation there is no excuse for the invention of new elements to explain these occurrences. The course of the responses here and of the accompanying consciousness present the usual characteristics of the process of habit formation. Making correct responses without being aware of it is the usual occurrence with perfected habits. The *Determinierenden Tendenzen* are merely habits.

There is also some evidence for interpreting the *Bewusstseinslagen* of Marbe,[1] Watt,[2] Messer,[3] and Bühler[4] as the conscious concomitants of highly practiced responses. As regards Marbe it is to be noticed that he observed them in correlation with responses to very simple problems, such as, What is the principal city in France? Translate 'Homo cogitat.' Are two and three six? How many are three times eight? To a graduate of a German university such problems could not provide much food for thought, and it is small wonder that most of the answers 'followed purely reflectively without further conscious processes' and that in many cases the subjects were conscious of nothing but the

[1] 'Experimentelle psychologische Untersuchungen über das Urteil,' 1901.
[2] *Arch. f. ges. Psychol.*, 1904, 4, 289–436.
[3] *Arch. f. ges. Psychol.*, 1906, 8, 1–224.
[4] *Arch. f. ges. Psychol.*, 1907, 9, 297–365.

sound of the question. Watt's experiment provided a better opportunity for observing the origin of the *Bewusstseinslagen*. His subjects during the early part of the experiment, in responding to stimuli under controlled association instructed themselves upon their task by repeating it in inner speech during the fore-period. Finally this process dropped away and the subjects became wholly unconscious of their tasks, but yet responded correctly to them in an objective way. In this stage the *Aufgabe* usually came to consciousness only in case of an error, *i. e.*, when the response did not agree with the *Aufgabe*, and a problematic condition again existed. Watt, therefore, has the problem of explaining a meaningful connection in a series of responses where the subject is not aware of it. Watt assumes that only some conscious factor can explain such an occurrence, and therefore makes the further assumption of an underlying *Bewusstseinslage* which directs the series of meaningful responses and which is in turn controlled by the *Aufgabe*. This would be a legitimate procedure if the explanation of conscious phenomena or of intelligent behavior would have to be restricted to the field of consciousness and if we were totally ignorant of the processes of reflex action and of habit formation in the nervous system. Since, however, unconscious action of the *Aufgabe* has all the marks of a mechanized response, why should we not be satisfied to call it a habit and explain it in terms of the known action of the nervous system rather than complicate the problem by the assumption of a *Ding an Sich* in the *Bewusstseinslage?* Watt, apparently, does not consider that a series of responses may have a meaningful connection objectively without its being so subjectively, that is, that a connection may be logical without being conscious. It is quite possible that a consciously meaningful connection may need the directive influence of a conscious *Aufgabe* without the same being true for an unconsciously meaningful or logical connection.

In this respect, Messer is truer to experience. He says that the consciousness of meaning may occur in various intensities 'from clear verbal images down to unanalyzable

Bewusstseinslagen.' The latter come in cases of automatic reactions and often after the reaction. This was the case in the meaning of *Maus* as a subordinate response to *Haustier.* He found that the consciousness of meaning as a distinct experience occurs only in such situations as the following: when a word is (1) strange; (2) misread; (3) has many meanings; (4) is pronounced like other words of a different meaning; and (5) when there were two long words in the stimulus. These conditions are all problematic and easily lend support to the view that only undefined responses are accompanied by a vivid consciousness. Messer recognizes the same view when he discusses the difference between newly formed and reproductive judgments. He says that the mode of appearance and the degree of development in a judgment depend upon its newness. "The more that a reproductive character sets in, the more the activity-character of the judgment process is lost, the factors that above all give to the judgment—experience and expression—the conscious and intentional predicative relation, the seeking, considering, testing, deciding, admitting, and rejecting—now come less to consciousness as such or not at all. The process becomes smoother and continually more automatic. . . . In this way it can easily happen that an experience of an often-repeated judgment can no more be conceptually distinguished from a pure associative reproduction."[1] The implication that *Bewusstseinslagen* are the concomitants of practiced acts is also contained in Messer's discussion on the divisions between the formulated and unformulated thought. The division in question is not sharp. "On the one hand, the limits would appear to be a thinking in completely formulated sentences with a clear consciousness of meaning. On the other hand, a lightning-like reflection and recognition in which there is no trace of a word; and the difference must be greater than that between the slow and correct writing of a child who has learned to write well, and the flighty symbols of a practiced stenographer."[2] For an explanation, he states there is the

[1] *Op. cit.*, 125–126.
[2] *Op. cit.*, p. 186.

evident hypothesis that real psychic processes can go on abbreviated and telescoped in many ways and demanding more or less psycho-physical energy.

Bühler in discussing the thought experiences admits that a small group of them consist of images, either of things or of words. But the most important constituents are devoid of images and of every sensory quality. These are the *Bewusstseinslagen*. We take it that his *Gedanken* are a species of the latter. The implication that they are the concomitants of highly practiced responses is indicated by his definition of them as 'the last experiential units of our thought life.'[1]

Opposed to this interpretation is his view that conscious meanings are a species of *Gedanken* or *Wissen* without sensory components, a functional description of thought. He also gives many examples of *Bewusstseinlagen* which are complex and new thoughts. If this is true, we could not classify them as the concomitants of highly practiced responses, but would rather have to consider them as thoughts which had not yet reached a phenomenal formulation. This is the view expressed by Woodworth in his presidential address.[2] If we accept introspection as a legitimate method in psychology there is simply no ground for denying the correctness of this view. On the same ground there is no good reason why it should not be placed at both ends of the practice period. In any case, however, the preponderance of evidence is in favor of placing it near the final end of this period.

Besides *Bewusstseinslagen*, Messer discovered other contents of thought which he calls objective and conceptional thoughts, and spheres of meaning (*Bewusstseinssphären*). The difference between the first two consists in the presence and absence of imagery respectively. The spheres of meaning are simply directions of meaning. His examples of the first two indicate that they are mainly different stages of the practice period: Objective (Swan-duck. Second series, 995). "Dim image of a pond upon which something like a swan was swimming. I did not see a duck, but said 'duck' in an objective

[1] 'Tatsachen und Probleme zu einer Psychologie der Denkvorgänge,' p. 329.

[2] PSYCHOL. REV., 1915, 22, p. 1ff.

sense (with a direction outward, externalization)." Conceptional: (Swan-duck. Third series, 872.) "Entirely automatic without any particular after-thought. Pretty much tension. No visual images present." We would explain the qualitative differences in the contents in the two cases as a result of the repetition of the same stimulus rather than as a ground for two distinct types of thought. With a further repetition of the stimulus, there undoubtedly would appear still less consciousness and at a certain point meaning would be present only as a mere direction. At this point, we would also classify Bühler's *Regelbewusstseinen*, *Beziehungsbewusstseinen*, and *Intentionen* and as the last experiential conscious concomitant of a practiced response we put the *Bewusstseinslage*. Following this we would classify the response as habit and finally as reflex action.

Summing up the conclusions which we have drawn from the results and statements in the experimental literature on the thought processes, we would say that the influence of practice on the conscious contents of thought is similar to that on associative aids and on such conscious contents that came to our notice. The qualitative content of consciousness is largely dependent upon the degree of practice in the response which it accompanies. If we would arrange these contents in their genetic order as the response develops from an unlearned act to a habit, we should place them as follows: sensation, perception, imaginal thought, conceptual thought, awareness with direction, awareness without direction, habit, reflex action. The last two are unconscious. As regards the rest, we consider that the apex of conscious clearness is reached in conceptual thought. As regards the conscious presence of sensory components, we should consider them as ending in conceptual thought. We believe that this classification could be made to appear defensible, if it were worth while doing so, and that it also could be shown to be free from most of the contradictions which Rahn has pointed out to exist in the analytic, structural, and sensational theories of consciousness. But from the point of view of this experiment, it makes little difference what the conscious contents,

sensory or non-sensory, of thought are. We wish to discover how thinking does its work, where it begins, and where it ends. In this problem, an introspective analysis of the sensory or non-sensory components of thought could help us hardly a whit. At most they might be a symptom of the stage of practice, but of these there are so many objective marks which can be more easily observed. Again, we have no means of telling whether these sensory or non-sensory components are of any importance in the work of thought. At least we venture to believe that the experimental literature up to the present has not proven them to be so, we mean proof in the scientific sense of the word, a proof that is verifiable independently of the personal equation of the prover. We admit the necessity of a stimulus and of a response, but that processes consisting of sensory components having the attributes of intensity, quality, duration, and a possible admixture of clearness, and those other cobweb-like structures which have a textural difference from sensation in that they are 'more filmy, more transparent, more vaporous,' and are 'relatively pale, faded, washed out,' and 'misty'—must occur between the stimulus and the response and be carriers of meanings, this we do not admit. We fear that if the mind were stuffed with such things, they would stifle the work of thought to death, but we await the scientific proof of their function.

We must now revert to the original questions, How does thought do its work? Where does it begin and end? We would answer: Thought does its work by means of association. It begins with a problem or *Aufgabe* and ends with a solution. Thought is a form of controlled association, that is, the associations are directed toward an end. The data of our experiment lead us to this view. We noticed that the learning of the associated pairs was accomplished by means of associative aids in most of the cases, and, in the rest of them, the association was direct. Later, the responses became fixed and mechanized and the associative aids dropped away. The subject reported that they thought of nothing in these cases. The responses had become habits. Then when the words

were to be learned in new orders, backwards, downwards, and upwards, we find associative aids coming up again, and the responses indefinite and slow. A new problem had occurred and again the associative devices were set into operation to solve it. If these solutions had been repeated as in the regular tests, we assume that they would have followed the same course and would have become habits in a short time.

The experiments of Ach, Watt, Messer, Bühler and Koffka are not in disagreement with this view, although all of these investigators make a sharp distinction between thinking and association. Watt characterizes thinking as a meaningful sequence of ideas under the direction of the *Aufgabe*. In this it is different from association, which is a haphazard and undirected sequence of ideas. Under the *Aufgabe* there occur also many new sequences of ideas while an association is a mere restatement of an old experience. Ach takes the same view, and because in thinking there is a meaningful and often a new sequence of ideas, he must have determining tendencies to account for it, and therefore classes them along with association and perseveration as determinants of consciousness. Messer also finds various connections between ideas some of which are merely reproductive and accidental and some of which are consciously intentional. He limits the term thinking to the latter. Like Ach, Koffka[1] assumes the existence of determining tendencies to explain the solutions to *Aufgabe*. The task is often solved with difficulty, but an associative reproduction would be easy. There is selection in the ideas accepted as correct, and this selection cannot be explained by association. The ideas solving the task also are intentional and frequently appear in a nonsensory form. But neither of these characteristics is contained in the conception of association. We agree with Koffka that if the term association is to be restricted to the old conception, *e. g.*, to that of James Mill, we must assume the necessity of some such factor as a determining tendency for the explanation of the meaningful and new sequence of ideas found in thinking. But we see no reason for restricting ourselves to the old con-

[1] 'Analyse der Vorstellungen und ihrer Gesetze,' 1912.

ception. The synapses of the nervous system admit of millions of connections, and we assume the same to be true of our various experiences and thoughts. Under the guidance of instinct and interest there is no reason why there should not be a spontaneity in the connections between ideas. With that spontaniety come new and varied sequences. As a matter of experience these spontaneous connections in ideas are the usual occurrence. It is seldom that an old experience is reinstated with the exact order of the original. In fact, this rarely occurs without training and practice. The fact that repetitions are needed in memorizing is sufficient proof.

G. E. Müller[1] gives an extended criticism of determining tendencies, *Aufgabe*, etc., in his recent work on memory. He aims to show how the conception of association is sufficient for explaining the unconscious solutions to *Aufgabe*. We cannot reproduce his many important arguments, but we think that he restricts himself too much to the adequacy of the old conception and does not sufficiently recognize the importance of spontaneity and of habit.

Admitting the spontaneity of associative connections, enables us to appreciate the valuable contributions which Messer and Bühler have made to our understanding of the work of thought in getting the meaning of words and of sentences, reproducing associate phrases, analogous proverbs, and the sense of sentences from the keyword. These show quite clearly how thinking is essentially controlled association. It is one of the valuable results that has come from the discovery of alleged imageless thought. Having found that the introspective analysis of sensory components comes to grief and that the major part of our thinking goes on without them, these investigators struck out in a new direction and began to investigate the dynamics of thought. Messer in this connection discovered the importance of *Bewusstseinssphäre* in the suggestion of meaning. The meaning may come in the suggestion of the sphere of a superordinate, of a coördinate, or of the entire field of the object. It may also be suggested

[1] 'Zur Analyze der Gedächtsnisthätigkeit und des Vorstellungsverlaufes,' III, *Zeit. f. Psychol.*, 1913, Erg.-Bd. 8, Sect. 126.

by an emotional state. Bühler did much more in this direction. He found that a sentence is usually understood by bringing it into relation with a more general principle from which it may be derived. But in some cases a sentence was understood by placing it in a schema, by recognizing its identity with a previous thought, or by translating it into a familiar form. The Analogy Tests brought out the associative character of thought more clearly. In these, E. read twenty familiar proverbs. These were followed by the reading of twenty other proverbs, each of which had a similar meaning to one in the first series. After hearing each one in the second series, the subject was to recall a similar proverb in the first series. In general the associative process was that the subject sought to comprehend the deeper meaning of the second proverb and while doing this a similar meaning in one of the first series occurred to him. Frequently the earlier thought was recalled through a generalized meaning of the thought and which was also valid for the earlier thought. The test thought also suggested the earlier one through a common single idea, a common word or phrase, a common whole meaning, a common sphere of meaning, or a common situation. All of these cases are good examples of association by similarity of meaning.

Although the members of the Külpe School seek to make a sharp distinction between thought and association, we interpret their results rather as showing that thinking is merely a species of association, that is, a controlled association.

We have noticed from the data of the experiment that these associative processes are employed in the solution of a problem only while it is problematic and that they drop away after the solution becomes fixed. We limit the term thinking to the associative process within the problematic stage and the fixed solution we classify as form of habit. In terms of formal logic the thinking would be called judging and the fixed solution a judgment. At least this is our psychological interpretation of these terms.

Summary V

The learning of paired associates may be treated as simple problems to be solved by thought. If so, we discover that associative aids have their highest frequencies during the problematic stages of thought and disappear as the solution becomes mechanical. This means that thinking does its work by means of association and when its work is done the associative process disappears.

Our observations indicate that the sensory contents of thought follow a similar course, an opinion which is amply confirmed by a review of the experimental literature on habit formation and on thinking. In the light of this view the numerous structural elements which the Külpe School has reported as existing in thought, such as Aufgaben, Determinierenden Tendenzen, Bewusstseinslagen, Gedanken, Regelbewusstseinen, Intentionen, etc., are quite unwarranted. So far as they exist they merely mark off different genetic stages in the development of thought from a problem to a habit. The qualitative content of thought is largely dependent upon the degree of practice in the response which it accompanies. We believe that these contents may be divided into the following stages of a genetic order: sensation, perception, imaginal thought, awareness with direction, awareness without direction, habit, reflex action. These distinctions, however, give us little help in understanding the real problems of thought: how it does its work, where it begins, and where it ends.

The distinction which the Külpe School draws between association and thinking is also unwarranted. The dynamics of thought may be fully explained by the concept of association. Thinking is a form of controlled association. It is merely a stage in habit-formation, beginning with a problem and ending with a habit. It does its work by means of associations and these disappear as the work approaches completion. Such a theory enables us to dispense with the fruitless quibbles over the multiplication of structural elements and makes possible practical studies of the dynamics of thought under a simple scientific concept which is in agree-

ment with modern physiology and scientific method. The discoveries of the Külpe School on the dynamics of thought instead of contradicting this theory really support it.

VI

Since both the methods and the conclusions of this experiment are at variance with the requirements of those who hold the sensationalistic theory of mind, we shall find it profitable to examine the differences and the justifications for them. As a representative of the sensationalistic theory I shall take Titchener and his school.

As a matter of method in this experiment I restricted my questions to demands for the reports of meanings thought of between the stimulus and the response. I never suggested that the subjects might have sensory or imaginal experiences in connection with these meanings nor did I ever ask questions which called for a report of these sensory experiences, if there were any. I therefore did not follow what Titchener calls the method of psychological description but instead the method which he calls the method of logic or of logical common sense. For brevity, I prefer to call it the method of objective report since the subjects report the objects of their thought, that is, their meanings or associations. I was tempted to do this partly because my subjects were not trained to report sensory experiences and partly because I was not inspired by the experimental studies which have been made by the method of psychological description. Bühler, in the course of his investigation, unconsciously drifted from the method of psychological description into the method of objective report. Titchener calls the latter method a failure because it commits the stimulus error. Yet I find that the observations reported by Bühler on sensations and images are the most worthless and unstable parts of his experiment. His important contributions to the future of psychology were obtained by the method of objective report. I refer in particular to his contributions to dynamics. If the studies made by the method of psychological description are lacking in valid judgments on dynamics, I attribute the results to

the method and not to the investigator. Let us examine by what method of reasoning the sensationalistic theory of thought is established. To avoid a lengthy discussion let us examine just one judgment that is frequently made by Titchener and the members of his school, namely that sensations and images are the carriers or constituents of meaning. I shall begin with Titchener.

"Meaning, psychologically, is always context."[1] "Meaning is originally kinæsthesis. . . . Afterwards, when differentiation has taken place, context may be mainly a matter of sensations of the special senses, or of images, or of kinæsthetic and other organic sensations, as the situation demands."[2] "As a matter of fact, meaning is carried by all sorts of sensational and imaginal processes."[3] "My 'feeling of but' has contained, ever since, a flashing picture of a bald crown, with a fringe of hair below, and a massive black shoulder, the whole passing swiftly down the visual field from northwest to southeast. I pick up such pictures very easily, in all departments of mind; and as I have told you, they may come to stand alone in consciousness as vehicles of meaning."[4]

Turning to Whipple's paper, 'An Analytic Study of the Memory Image and the Process of Judgment in the Discrimination of Clangs and Tones,' we find him reporting that Observer F.'s judgment is often conditioned by a loosening of the muscles of the scalp on the left side of the head or by a tightening of the muscles of the ear or by moving the head up and forwards, or by a pressure upward in the head. But he also makes many judgments without the presence of an image.

In Bagley's 'Apperception of the Spoken Sentence,'[5] we are told that no conscious 'stuff' was found which could not be classed as sensation or affection when reduced to the ultimate by a rigid analysis. The kinæsthetic elements are predominantly marginal elements and the marginal elements carry the meaning. "The apperception of auditory symbols involves the presence in consciousness of visual and verbal

[1] 'Text-Book,' p. 367.
[2] 'Exp. Psychol. of the Thought Processes,' p. 176.
[3] *Op. cit.*, p. 178.
[4] *Op. cit.*, p. 185.
[5] *Am. J. of Psychol.*, 1900, 12, 80–130.

ideas mainly; . . . the auditory and kinæsthetic elements seemingly form a small part, and the temperature, taste, and smell elements a still smaller part of this 'stuff.'" Some illustrations of the evidence upon which these statements are based are interesting..

"Not a man ha(s) had his vote refused him." L. visualized a voting card and a polling station. The vote was upon the 'license' question. The consciousness of this last reference took the form of the word 'temperance' printed with a capital T. There was some excitement about the city which in the ideal reproduction took the form of voice memories."[1]

"The safe door was closed with a sna(p) and the cashier was a helpless prisoner." With this sentence Wh. had a vague visualization of a man standing in the inside of a bank office. The safe door was back of him. He was a tall man with a smooth face and a derby hat. He had a notice in his hand and appeared to be startled at something; he was the cashier. (In this case, as in many other which we shall cite later, the reference was not in every way consistent with the context.)"[2]

"'He had lost ho(pe) in the unequal struggle.' Wh. felt sorry for the poor beggar."[3]

"'Fi(r)ing too high is a common mistake.' C. . . . noticed a general tension in trying to get a word for fi(r)ing—a strain about the eyes and chin."[4]

Helen Maud Clarke in her paper on 'Conscious Attitudes'[5] finds that they 'can be analyzed into sensations and images and feelings,'[6] and bases her conclusions on reports like the following:

The task of 'hurry up.' G. "Organic sensations from diaphragm. The muscles of the diaphragm seem to come up and press the lungs, and the muscles of the ribs seem to tighten."[7]

[1] *Op. cit.*, p. 108.
[2] *Op. cit.*, p. 109.
[3] *Op. cit.*, p. 124.
[4] *Op. cit.*, p. 125.
[5] *Am. J. of Psychol.*, 1911, 22, 214–249.
[6] *Op. cit.*, p. 249.
[7] *Op. cit.*, p. 231.

"Some of the reports show that the meaning of a word may be carried in whole or in part, by a motor image or an organic sensation: *Grip*. Visual image of a hand reached out to grasp something, and muscular image of the sensation in the right arm and hand when something is grasped."[1]

Probably the best examples of sensory meanings are given by Jacobson in his paper on 'Meaning and Understanding.'[2] A written word was laid before the subject for one minute. The last ten seconds were marked off by a signal, and the subject's task was to report what occurred in consciousness during this particular interval.

Obs. F., Stimulus, *heavily*. "An unclear auditory image of the noise. Strains in ear drum; organic sensations in the abdomen such as are involved in hearing a weight dropped, and such images as one would get from a jar of the building. . . . Tendency to nod head synchronously with the utterance: meant 'heavily.'"[3] The conclusion drawn is as follows: "The meanings of the stimulus words were thus carried by visual, auditory, and kinæsthetic processes; or to speak more precisely, the meanings which these processes bore were the meanings of the stimulus words, in so far as the latter were consciously realized."[4]

It may not seem just to criticize a method of which Titchener has said, after reviewing the experiments of Okabe, Clarke, Jacobson, and others, "A just appraisal will hardly give it rank with the approved methods of the science."[5] His objections are that the method in question cannot settle disputed questions of a systematic kind, or enable us to compose the issue between imageless and imaginal thought, or prove or disprove the existence of a 'form of combination'; and its results must admit of various interpretations and be subject to the charge of arbitrary selection. I agree with the objections and I should not say more, were it not for the fact that in the same paper he upholds Clarke's position that

[1] *Op. cit.*, p. 239.
[2] *Amer. J. of Psychol.*, 1911, **22**, 553–557.
[3] *Op. cit.*, p. 566.
[4] *Op. cit.*, p. 564.
[5] 'The Method of Examination,' *Amer. J. of Psychol.*, 1913, **24**, p. 440.

sensations and images are carriers of meaning. He upholds this position against Koffka's criticisms which were that sensory contents may be (1) irrevelant for thought; (2) a condition of thought, and (3) thought itself. Koffka finds fault with the author for recognizing only the third alternative to the neglect of the other two. Titchener replies that this criticism denies the possibility of psychological analysis in any field, *e. g.*, that the chord, c, e, g, could be analyzed into tones and noise.

I do not agree with this reply, but I insist that a judgment of a necessary connection in psychological phenomena must be grounded scientifically and logically in the same way as they are in any other science. It is one of the elementary lessons in logic that the occurrence of two events either simultaneously or in immediate succession is no proof that they are necessarily connected. Hume, to whom we are much indebted for the sensationalistic theory, has clearly shown this. I need scarcely recall J. S. Mill's five canons of experimental inquiry or the theory of probability in this connection, but the alleged connection between sensory components and meaning has not yet been verified by any of the approved canons of scientific judgment. Some sensationalists themselves admit the occurrence of imageless judgments and comparisons, *e. g.*, Bentley and Whipple. If the quality of the imagery is indifferent there ought to be at least some constant relationship between its amount and the amount of meaning or between the frequency of the imagery and the frequency of the meanings; but Clarke herself says that in thinking in verbal images 'it is by no means necessary to say every word which we should use if we were talking aloud.'[1] Even Titchener admits any quality or degree of imagery without a loss in the meaning, as in the recognition of a gray, and goes so far as to say that meaning may be carried in purely physiological terms.[2] The latter would be a meaning without sensations and images. If this is true, it is sufficient to disprove any necessary connection between sensory components and meaning.

[1] *Op. cit.*, p. 224.

[2] 'Ex. Psychol. of the Thought Processes,' p. 178.

Again, if the connection between meaning and sensations or images is necessary, those who investigate it by the same method ought to agree with one another. But of three men who are equally expert in introspection, none will reach the same conclusion. Jacobson, for example, asserts that sensations and images carry meanings. Watt and others of the Külpe School assert that there are imageless meanings, and Müller-Freienfels asserts that images are the *consequences* of thought and in no way the causes of the material of thinking.[1] The conclusion must therefore rest upon the personal equation of the investigator, which is another sufficient refutation of the alleged connection.

The occurrence of sensations and images may be due to many circumstances and may be independent of any connection with meaning except a temporal one. Titchener's image of a bald head when he thinks of 'but' may be a mere perseveration. The muscular movements of Observer F. which Whipple says condition F.'s judgments may be symptoms of indigestion only. When Bagley's observer Wh. sees a bank cashier with a startled look, a smooth face, a derby hat, and a valise in his hand, after hearing the sentence, 'the safe door was closed with a sna(p),' etc., the latter may simply have reminded him of a debt past due. When Clarke's Observer G. observes that the task of 'hurry up' consists of organic sensations from the diaphragm, or movement upward of the diaphragm, and a tightening of the muscles of the ribs, is it certain that the patient did not eat too many beans and too much bacon for breakfast? When Jacobson's Observer F. experiences various auditory, kinæsthetic, and other sensations as the meaning of the word 'heavily' after looking at it for fifty seconds, are not these experiences most naturally explained as a result of a changed direction of attention? A graduate student would not find much food for thought in looking at this word, and naturally he would turn his attention inward and observe the feelings of his organic processes. The latter would be all the more probable because of the instruction to get as much experience as possible in the

[1] *Zeit. f. Psychol.*, 1911–12, 60, p. 443.

last ten seconds. If some of these explanations are not scientific, is there not just as much logic in their favor as for the proposition that sensations and images are carriers of meaning? All that we ask is that such a proposition be proved in accordance with the approved canons of scientific judgment. In any case, we hope that our method of objective report has not proven less scientific or fruitful than the method of psychological description.

Summary VI

So far as the observers' reports are concerned, the method of this experiment was restricted to a report of the meanings or associations of thought between the stimulus and the response. It may be called the method of objective report, and as such is distinguished from introspection in its refined form of psychological description. The latter is based on the assumption that a causal connection in mental phenomena is a matter of immediate observation. This is illustrated in the evidence for the judgment that images carry meanings. Such a judgment ignores the most elementary lessons of logic and is not based on any approved canon of scientific judgment. In fact it is on a level with primitive thought, which takes an observed contiguity of two events as ground for a causal connection without a critical disproof of other possible explanations. In comparison to this the method of objective report when supplemented by a statistical treatment of its results is no less scientific. On the contrary we believe that it gives not only practical but also verifiable results.

COMMUNITY OF IDEAS

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The writer presents here some data relating to community of ideas. The experiment is the 'Class Experiment on Community of Ideas' prepared by E. G. Boring and G. M. Whipple and circulated among the members of the American Psychological Association some few years ago. The purpose of the experiment, according to Boring and Whipple, is "to demonstrate the existence of a high degree of likeness in the association of ideas of individuals when placed under like conditions and to measure the degree of this likeness in a number of instances."

Twenty stimulus words were used, the ten words of the experiment proper, and the additional ten words of what is called 'Supplementary Experiment *B*,' being words that are not supposed to show as much community as the first ten words. The following procedure, as described by Boring and Whipple, was followed: "See that the members of the class are provided with pencil and paper. Instruct them as follows: 'You will be asked to close your eyes and then to think of something that belongs to a general class, for instance, of any musical instrument, of any amusement, of any algebraic symbol. When the class of thing to be thought of is announced, notice what particular thing of that kind comes first to your mind. Do not search for anything else, but at once open your eyes and write the particular thing you thought of. Number the items you write to accord with the numbers of the trials as announced.' Give the following instructions and preface each with the command: 'Ready. Close your eyes. (1) Think of any color,' etc."

The observers have been divided into three classes: (1) University students, (2) school children aged thirteen and above, (3) school children aged twelve and below. The

university students numbered 739 for the first ten words and 567 for the last ten. There were 236 older children and 119 younger children. The data for the students were gathered during several years from several classes in elementary psychology. The first group consisted of 150 students and as each successive group was tested the results were added to the preceding results and the percentage frequencies were calculated. For the first ten words eleven groups were added to the original group, making twelve series of percentages for the occurrence of each association; for the second ten words nine additional groups were added, making ten series of percentages. A study of these percentages gives a measure of the stability of the frequency of each response. Long before the last group was added to the total these percentages on the whole showed little variation, an indication that the frequencies of the responses may be considered typical of students in psychology.

The data for the children were not treated in this manner because the numbers were not large enough. It is, of course, impossible to print all the successive percentages calculated for each response to each stimulus-word. The data would cover many printed pages. The general nature of the fluctuation of the percentages is obvious. During the addition of the first few increments the percentages tend to vary somewhat, while each new increment added tends to decrease this fluctuation. The average deviation of the percentages will be a measure of the stability of the percentage frequency. We have calculated this for the last six increments. This means the addition of 419 individuals in six increments. These average deviations for the three commonest responses are given.

Table I. gives the twenty stimulus words with their three commonest responses, the percentage of individuals making such response, the average percentage for the last six increments and the A.D. of these last six percentages. The small average deviations show very clearly the stability of the percentages for the commonest associations. If a class of university students in psychology is asked to 'think

TABLE I

THE THREE MOST FREQUENT RESPONSES—ADULTS

Stimulus	First Choice	Percent	Last Six Increments		Second Choice	Percent	Last Six Increments		Third Choice	Percent	Last Six Increments	
			Av. Percent	A.D.			Av. Percent	A.D.			Av. Percent	A.D.
1. Color	Red	61	64.1	2.0	Blue	26	24.9	1.3	Green	5	4.6	0.8
2. Furniture	Chair	80	81.2	2.0	Table	8	8.1	0.7	Bed	3	1.8	0.4
3. Flower	Rose	61	60.1	0.7	Violet	10	10.0	0.3	Pansy	6	6.2	0.2
4. Letter of the Alphabet	A	76	77.1	1.6	B	8	8.1	0.1	Z	2	2.2	0.2
5. Metal	Iron	46	47.0	1.3	Gold	29	29.9	0.5	Silver	5	5.5	0.3
6. Historic Personage	Washington	50	50.1	0.6	Napoleon	14	14.4	0.4	Lincoln	10	10.3	0.5
7. Part of Speech	Noun	46	49.0	2.7	Verb	36	35.0	1.2	Adjective	5	4.4	0.1
8. Geometrical Figure	Triangle	43	41.0	1.2	Square	23	25.4	1.7	Circle	11	11.0	0.3
9. Verb	Run	27	27.1	0.5	Go	24	23.7	0.3	Be	7	6.9	0.05
10. Tool	Hammer	46	45.3	1.3	Saw	14	11.8	1.2	Hatchet	8	8.7	0.4
11. Article of Food	Bread	52	51.6	0.6	Meat	7	6.8	0.3	Potatoes	6	6.8	1.5
12. Part of Body	Arm	35	33.0	1.3	Hand	23	24.3	1.4	Head	17	17.5	0.4
13. Day of Week	Monday	46	45.8	0.4	Sunday	20	20.0	0.6	Wednesday	10	8.7	0.8
14. Room in House	Parlor	28	28.6	1.2	Dining	18	16.0	1.7	Kitchen	13	13.3	0.7
15. Animal	Dog	37	34.8	2.3	Horse	27	27.1	0.8	Cat	16	16.0	0.6
16. Book	Psychology	12	13.9	1.1	Bible	6	8.8	1.9	Les Miserables	3	3.0	0.2
17. Girls' Name	Mary	20	29.0	1.0	Helen	9	9.0	0.6	Ruth	8	6.2	1.5
18. Source of Sound	Bell	15	18.2	2.7	Whistle	12	12.3	1.0	Piano	11	10.7	0.4
19. Date	Past	38	35.5	1.5	Recent	28	30.1	1.7	Future	16	14.5	2.3
20. Country	America	27	27.0	0.8	U. S.	20	19.7	0.5	Germany	16	16.0	0.7

of any color,' about sixty per cent. of the class are likely to think first of the color 'Red,' and so on with the other responses. The stability of some of the percentages is remarkable, as in the case of 'Flower—Rose' with an average percentage of 60.1 and an A.D. of 0.7; and 'Historic Personage—Washington' with an average percentage of 50.1 and an A.D. of 0.6. The highest percentage occurs with 'Furniture—Chair,' namely eighty per cent. The three commonest associations to 'Color,' namely 'Red,' 'Blue,' 'Green,' account together for ninety-two per cent. of all responses, leaving only eight per cent. of the responses to be distributed over all the other colors. In fact a study of the table impresses one with the great likeness in the association of ideas of individuals. The number of responses possible to the stimulus-word 'Verb' is very great, and yet the two responses 'Run' and 'Go' together account for over fifty per cent. of the responses.

Table II. shows the condensed results for the adults.

TABLE II

ADULTS

Stimulus	Word	Percent	Words Given Most Frequently								Failures, Percent
			By 25 % or Over		By 5 % or Over		By 2 % or Over		By Less Than 2 %		
			No. of Words	Total Percent	No. of Words	Total Percent	No. of Words	Total Percent	No. of Words	Total Percent	
1. Color	Red	61	2	87	3	92	5	96	6	4	0
2. Furniture	Chair	80	1	80	2	88	4	93	18	7	0
3. Flower	Rose	61	1	61	4	82	7	90	25	10	0
4. Letter of the Alphabet	A	76	1	76	2	84	4	88	20	12	0
5. Metal	Iron	46	2	75	3	80	8	06	9	4	0
6. Historic Personage	Washington	50	1	50	3	74	6	83	64	17	0
7. Part of Speech	Noun	46	2	82	3	87	6	95	12	5	0
8. Geometrical Figure	Triangle	43	1	43	3	77	9	92	17	8	0
9. Verb	Run	27	1	27	3	58	12	80	68	20	0
10. Tool	Hammer	46	1	46	5	80	8	88	29	12	0
11. Food	Bread	52	1	52	4	70	6	75	52	25	0
12. Part of Body	Arm	35	1	35	4	80	6	86	23	14	0
13. Day of the Week	Monday	46	1	46	5	92	7	98	0	0	2
14. Room in a House	Parlor	28	1	28	6	86	9	94	12	5	1
15. Animal	Dog	37	2	64	4	85	6	91	21	9	0
16. Book	Psychology	12	0	0	2	18	9	35	164	64	1
17. Girl's Name	Mary	20	0	0	3	37	15	64	86	35	1
18. Source of Sound	Bell	15	0	0	4	43	13	69	68	29	2
19. Date	Past	38	2	66	4	94	—	—	—	—	6
20. Country	America	27	1	27	6	82	9	89	24	10	1

The most frequent response with the percentage of frequency is shown, then the total number of words named by twenty-five per cent. or more of the individuals, then the total number named by five per cent. or more, and the total number named by two per cent. or more. The next to the last column shows the number and percentage of words named by less than two per cent. This is one measure of the amount of 'scattering' in the responses. The last column shows the percentage of failures to make any response to the stimulus word, or failure to follow the directions of the experiment.

A glance at the number of words given by twenty-five per cent. or over shows that no stimulus word called forth more that two such responses. Five words called forth two such responses, twelve words had only one response with a percentage of twenty-five per cent. or over, and in three cases the commonest response fell below twenty-five per cent.

The last ten words were supposed by Boring and Whipple to be likely to show less community than the first ten words.

TABLE III

OLDER CHILDREN

Stimulus	Word	Percent	Words Given Most Frequently								Failures, Percent
			By 25% or Over		By 5% or Over		By 2% or Over		By Less Than 2%		
			No. of Words	Total Percent	No. of Words	Total Percent	No. of Words	Total Percent	No. of Words	Total Percent	
1. Color	Red	46	2	77	5	94	7	99	4	1	0
2. Furniture	Chair	70	1	70	3	87	6	95	9	5	0
3. Flower	Rose	52	1	52	4	76	8	88	17	12	0
4. Letter of the Alphabet	A	69	1	69	2	77	8	93	18	7	0
5. Metal	Gold	41	2	66	5	85	9	96	4	1	3
6. Historic Personage	Washington	45	1	45	4	68	6	73	37	20	7
7. Part of Speech	Noun	54	2	80	2	80	5	89	6	3	8
8. Geometrical Figure	Triangle	26	1	26	4	61	4	61	14	9	30
9. Verb	Run	25	1	25	4	55	9	71	34	21	8
10. Tool	Hammer	53	1	53	3	78	9	91	13	8	1
11. Food	Bread	51	1	51	3	74	7	84	24	16	0
12. Part of Body	Arm	27	1	27	6	77	12	94	12	6	0
13. Day of the Week	Monday	48	1	48	4	91	7	100	—	—	0
14. Room in a House	Kitchen	24	0	0	5	91	7	96	7	4	0
15. Animal	Horse	40	2	66	4	83	7	92	13	8	0
16. Book	History	16	0	0	4	35	12	59	85	41	0
17. Girl's Name	Mary	17	0	0	2	23	15	58	70	42	0
18. Source of Sound	Piano	11	0	0	6	42	16	68	47	21	11
19. Date	Past	43	2	79	3	85	3	85	1	1	14
20. Country	America	24	0	0	5	82	9	93	10	6	1

For half of the words in question this seems to be the case. Numbers sixteen, seventeen and eighteen show the greatest amount of scattering. Number nineteen would show a great deal more if each separate date had been tabulated. Number eleven shows a fairly large amount of scattering in spite of the fact that the most frequent response has a high percentage. The other five words are not characterized by a great amount of scattering. There are three or four words among the first ten showing quite as much scattering as these five words.

Tables III. and IV. show the data for the children arranged in the same way as in Table II. for the adults. In general the characteristics of the children are the same as those of the adults, except that the percentages for the most frequent words are generally not quite so large, while the percentage of failures is much larger. With the younger children the percentage of failure amounts in some cases to over fifty per cent.

On the whole we may say that the more common responses

TABLE IV

YOUNGER CHILDREN

Stimulus	Word	Percent	Words Given Most Frequently								Failures, Percent
			By 25% or Over		By 5% or Over		By 2% or Over		By Less than 2%		
			No. of Words	Total Percent	No. of Words	Total Percent	No. of Words	Total Percent	No. of Words	Total Percent	
1. Color	Red	49	2	78	4	90	6	96	3	1	3
2. Furniture	Chair	66	1	66	2	74	7	89	2	1	10
3. Flower	Rose	38	1	38	4	57	12	76	8	5	19
4. Letter of the Alphabet	A	37	1	37	2	44	10	64	7	13	23
5. Metal	Gold	35	1	35	3	50	6	60	1	1	39
6. Historic Personage	Washington	14	0	0	2	27	9	44	20	18	38
7. Part of Speech	Noun	18	0	0	2	34	3	36	4	3	61
8. Geometrical Figure	Square	16	0	0	3	32	4	35	1	1	64
9. Verb	Run	18	0	0	2	26	4	32	10	7	61
10. Tool	Hammer	52	1	52	3	74	5	80	5	4	16
11. Food	Bread	38	1	38	5	75	9	85	15	12	3
12. Part of Body	Head	18	0	0	6	59	14	80	8	5	15
13. Day of the Week	Monday	47	1	47	6	85	7	89	—	—	11
14. Room in a House	Bedroom	24	0	0	6	83	7	85	1	1	14
15. Animal	Horse	36	1	36	5	78	9	87	9	5	8
16. Book	History	15	0	0	3	30	12	58	31	27	15
17. Girl's Name	Mary	8	0	0	3	21	23	72	27	17	11
18. Source of Sound	Piano	10	0	0	5	35	17	65	18	12	23
19. Date	Recent	27	1	27	3	53	—	—	—	—	47
20. Country	Town or county	26	1	26	5	65	9	75	5	4	21

for the students are also the more common responses for the children, though the frequencies of occurrence often vary considerably. In general it is interesting to note that of all the associations possible to some stimulus words, how relatively few are chosen by two per cent. or more of the observers. Taking the stimulus words in order we note that 'Red' and 'Blue' are the two most common associations to 'Color' both for children and adults. For 'Furniture' the four most common associations for adults and children are 'Chair,' 'Table,' 'Bed,' and 'Desk.' There is a greater variety in the responses to 'Flower.' 'A Letter of the Alphabet' calls forth 'A' and 'B' as the two most common responses, but after that there is not much similarity. The younger children show a large percentage of failures. In response to 'Metal,' the three most common associations are 'Iron,' 'Gold,' and 'Silver' for both children and adults. 'Washington' leads in 'Historic Personages' and is followed by 'Napoleon' for the adults and by 'Columbus' for the children. 'Napoleon' does not occur in the lists for the children. The children's responses suggest the influence of recent history lessons. 'Verb' and 'Noun' are the most common 'Parts of Speech.' More than half of the younger children fail to understand this stimulus word. The adults show a large selection of geometrical figures, whereas a great many of the children fail to understand what is required.

'Run' is the most common response to 'Verb' for both children and adults, and it is difficult to explain why this should be the case. 'Run' is an extremely common word and is used in a great many senses, although in many cases not as a verb. The associations of a verb with doing something—an activity—may be a partial explanation. 'Hammer,' 'Saw,' and 'Hatchet' are the three most common tools for children and adults. There is not the great variation in response to 'Food' as might have been expected. The younger children differ somewhat in the most common response to 'A Part of the Body,' but the variation is not great. 'Monday' and then 'Sunday' show the largest percentages for 'Day of the Week.' The factor of primacy, first of a series, is no doubt the ex-

planation here, as it was in the case of the response to 'A Letter of the Alphabet.' The most common response to a 'Room in a House' is different for each of the three groups. 'Dog,' 'Horse' and 'Cat' are the three most common responses to an 'Animal' for both children and adults, although the children respond most frequently by 'Horse' and the adults by 'Dog.' It is interesting to note how very few of all the animals in the world occur among the responses.

When we come to the 'Name of a Book' we find a very great amount of scattering of responses. More than sixty per cent. of the adults give responses that occur very seldom. The response that occurs most frequently is the name of the psychology text that is used. The 'Bible' follows with a frequency of six per cent. 'Les Miserables' is the third most common response. There is no explanation to offer for this. The A.D. for 'Les Miserables' is 0.2, showing that its position is not due to any chance group of students who happened to be studying it at some particular time. The books mentioned by the children reflect strongly their school environment. There is a great variation in response to 'A Girl's Name,' although the most common response is the same both for children and adults. 'A Source of Sound' also shows relatively little community. In tabulating the response to 'Think of a Date, giving day of month, and year,' the responses were grouped under four headings, 'Past,' 'Recent,' 'Future' and 'Day of the Experiment.' If this had not been done the variety of responses would undoubtedly have been greater than the variety resulting from any other of the stimulus words. The response to 'Country' puts 'America' first for the older children and adults, but for the younger children we have a misunderstanding of the meaning of 'Country' resulting in their responding by giving the name of the town or county in which they live. We also note that six per cent. of these younger children respond by the name of a state. The relatively large percentage of responses received by 'Germany' is undoubtedly due to the fact that all these data were collected since 1914.

On the whole the striking points seem to be, (1) the narrow

range of variability in the responses, (2) the great similarity between children and adults, and (3) the stability of the frequency percentages of the commonest responses. The comparison with children would seem to indicate that for the greater number of these stimulus words the responses obtained from university students would not differ radically from those that might be obtained from the total population.

The percentages attached to each word may be used as the score for that word and in this way any subject's paper may be scored. The score will show the degree of 'community' expressed by all his reactions. Using the first ten words of the experiment we have calculated the scores for twenty adults and ten children each at ages fifteen, thirteen, eleven, nine, and seven. The percentage frequencies for adults were used in scoring all the papers. The total possible score is 536, *i. e.*, if the most common response were given for each of the ten words. None of the seventy subjects whose papers were scored reached this total. The nearest approach to it was a score of 473 made by an adult. The average and median scores for each of these groups are as follows:

Age	Adult	15	13	11	9	7
Average	387	380	373	320	187	146
Median	407	394	400	325	213	174
Range Highest	473	454	472	416	323	294
Range Lowest	162	281	271	171	26	13

There is a distinct decrease with age. Some of this is, of course, due to the inability of the younger child to comprehend instructions. None of the seven-year-olds reach the median of the eleven-year-olds. The range of scores in each group is very great. It would be interesting to study the relation of the degree of community of ideas, as measured in some such fashion, with the degree of general intelligence possessed by a subject.

PSYCHOANALYTIC CONCEPTS AND RE-EDUCATION

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It has become a commonplace to criticize the Freudian conceptions on the ground that they detain us in the realm of mythical abstractions instead of allowing us to pass on to the ascertainable relations that a descriptive and explanatory psychology sets out to discover. The underlying conception of a frustrated *Libido* that, Caliban-like, sulks and schemes in the depths of the unconscious, tends to obscure the concrete factual relationships between the psychological phenomenon and the physiological processes upon which it depends. This criticism is amply justified. . . . But insofar as the psychoanalysts obtain results in the practice of the art of healing and directly attribute these results to the alleged fact that Freud's terminology "penetrates causes . . . and provides a means of reëducation,"[1] the manner in which these concepts function in bringing about these results presents in itself a problem that the psychologist may study. His purpose may be either that of understanding the mechanisms of mind that underlie mental healing or that of further developing suitable methods for applying psychological principles to the art. It is the first of these purposes that motivates the following analysis of the rôle of the conception of the *Libido* in the practice of the psychoanalysts.

Four Factors in the Art of Mental Healing

Four factors that enter into the art of mental healing are (1) diagnosis of the disorder in terms of a clinical picture, (2) enthusiasm on the part both of physician and of patient, (3) a formulation of some sort of picture of the normal function-

[1] Jelliffe, S. E., *J. of Phil., Psychol., &c.*, 1917, **14**, 270.

ing of the mechanisms involved, and (4) the release of the mechanisms that effect the reëducation.

Concerning the worth of the first of these factors little need be said here. The need for diagnosis is obvious. It is the first step in the scientific treatment of disease, but it is not the only step. Writing about the work being done today along the line of mental tests, Miss Martin[1] notes that nearly everywhere this work seems to end in the diagnosis, and that the therapeutic significance of what is learned from the diagnosis is too much ignored. Similarly, we find a vast literature in psychopathology of a diagnostic sort, that often invites the reader simply to share in the scientific delight over the discovery of a rare instance of some pathological phenomenon! And this is the case only too often in many of the discussions of the pathology of sex. To wade through these discussions is a tedious task—not so much on account of the pictures of human lives like lyres jangled and out of tune, but rather on account of the ever-recurring picture of lutes with one string on which no changes may be played. The picture of the normal may be illumined thereby,—but also, it may be obscured. Putnam writes that "few physicians read the works of v.Krafft-Ebing, Magnus Hirschfeld, Moll, and others of like sort."[2] It may be as Putnam believes on account of the taboo, but I recall the words once dropped by a successful and conscientious medical practitioner: "Psychopathology makes me tired. The less I know about the clinical picture, the better I am able to help the patient."

The evident appeal that Freud has for the healer, lies elsewhere than in the clinical pictures that he presents. He offers not only analyses and classifications of the abnormal, but in some subtle way he supplies enthusiasm and a program for action, or in the words of Jelliffe, 'a tool for again entering into facts and thus controlling them.' Herein lies, pragmatically, the virtue of Freud's system. Also this is why it is to be preferred, according to Jelliffe, to any contribution thus far made either by academic psychology or by behaviorism.

[1] Martin, L. J., *Science*, 1917, **44**, 393–399.

[2] *Vide* Freud, S., Three Contributions to a Theory of Sex, New York, 1916, p. vii.

He tells us that Freud's terminology "penetrates causes and beginnings and provides a means of reëducation and redistribution of effect involving adequate discharge, before which the colorlessness and ineffectualness of an ideal behavioristic reëducation plainly reveal themselves. . . ."[1] Besides clinical pictures there "is that revivifying quality which preeminently distinguishes Freud's thought and which his followers have caught."[2] In fine, let us note that Freudianism apparently induces in Jelliffe and other healers a fervor and an enthusiasm which, if it infect the patient also, must go far toward reëstablishing a normal functioning in the psychophysical organism.

The third factor,—one that has never been adequately recognized by the critics,—is Freud's constant reference from the pathological to some sort of picture of the normal functioning of the mechanisms involved. We may, with Kraepelin,[3] look with concern upon the airing at any price of all possible sexual ideas both in education and in medicine. It may be the better part to respect the inhibitions that, according to Freud,[4] nature herself tends to build up in the developing personality. But whatever the wisdom of Freud's analytic procedure in actual practice, the fact remains that his whole method has led him at the same time to construct a picture of the kind of psychophysical organism the patient is to become; and in consequence he has developed, more completely than anyone else, out of the mass of concrete data on the human sex-life that his profession has enabled him to gather, a picture of normal ontogenetic development that represents a valuable contribution.

But these three factors alone—viz., analysis of the disorder, enthusiasm, and formulation of the ideal of behavior,—do not ensure a reëducation in the direction of the *realization* of the ideal as overt behavior. Experience has taught us that they may lead rather to mere sentimental day-dreaming alongside of which the old habits of muscular and gland-

[1] Jelliffe, S. E., *J. of Phil., Psychol., &c.*, 1917, 14, 270.

[2] Jelliffe, S. E., *op. cit.*, 272.

[3] Kraepelin, E., *Psychiatrie*, Leipsic, 1915, v.

[4] Freud, S., Three Contributions to a Theory of Sex, New York, 1916, p. 40.

ular reaction persist unchanged. There is a fourth requisite: the release of the mechanism of reëducation itself, a factor that accomplishes the transition from the undesirable to the desired form of behavior.

Functionally this fourth factor consists in a *redirection* of the neural excitation, not only in such a way as to obtain a new perceptual and ideational pattern, but also in such a way as to effect a propagation of the neural excitement over the appropriate efferent pathway. This involves in the first place not only a raising of the threshold for the old system of undesirable habit-arcs, but also a lowering of the threshold for the new system. And secondly, it involves not only attention to the new stimulus, the new ideal, but also a relaxation of that attention in order that the new response may occur. For the chief enemy of the new behavior is not necessarily the old established behavior-pattern, but it may consist in the process of prolonged attention to the new stimulus,—thus preventing the neural discharge to the glands and to the gross musculature of the body. Instead of overt action, we then have the consciousness of the stimulus. (This is a point that the behaviorists do not always adequately recognize.) Thus the 'ideal' may be said to harbor within itself the very mechanism that may frustrate its realization. It is therefore incumbent upon the healer to understand and to control the psychological mechanisms involved in reëducation, unless a kind Providence has already equipped him completely with the tact and the insight that make of him a natural healer.

The Process of Reëducation

When we inquire into the nature of the process of reëducation, we find that it involves two phases: first a new psychophysical set, a new patterning of the determining tendencies, must be created, and secondly the control of the mechanisms that release the new behavior when the stimulus is presented, must be insured.

Whatever may be the neural mechanism of voluntary action,—a moot point—it does seem to involve, physiologically, a preparation or readiness of the efferent path of the

arc so that at the moment when the refractory phase (?) supervenes in the act of attention to the stimulus, the excitation is readily propagated into and over an efferent path already primed and therefore of low resistance at all synaptic points from motor center to muscle or gland.

Psychologically, the burden of all latter-day discussions of voluntary action is that, contrary to the assumption involved in the principle of dynamogenesis, the 'idea' does not necessarily 'go over' into appropriate action. Ach,[1] in his attempts to state the facts of voluntary action in terms of principles, developed the conception of the 'determining tendency' which, in neural terms, involves the setting of the neural arcs in such a way that certain systems tend to be facilitated and certain other, antagonistic, ones to be inhibited. Broadening the conception, the determining tendency may be conceived either as an instinctive one, such as the hunger-set which the comparative psychologist may control in an animal for experimental purposes, or as an acquired one, such as the 'office set' of a business-man, under the influence of which the acts and ideas that are held in readiness will be very different from those which are in readiness when the 'at-home set' supervenes.

But besides this determining tendency that ensures the *preparation* of the paths into which the neural excitation may ultimately go, there must be, according to Ach, another factor that ensures the *release* of the appropriate act. In the behavior of the psychophysical organism the act of attending to the stimulus must be followed by the act prepared for,—else we have an organism lost in the contemplation of the stimulus. The factor that ensures this release of the specific act for which the organism has been prepared by the determining tendency, is, according to Ach, a mental attitude: "*Ich will wirklich.*"

Ach's account is based upon the analysis of highly conscious voluntary action, and this 'actual moment' of his, this "*Ich will wirklich,*" savors somewhat of the Jamesian *fiat;* yet the same factor is discovered also in the analysis of acts

[1] Ach, N., Ueber den Willensakt und das Temperament, Leipsic, 1910, 237–249.

that are not so definitely volitions of a highly conscious sort. In Miss Washburn's analysis[1] we come upon the 'activity attitude' which, as an essential factor in purposive action, corresponds to Ach's '*Ich will wirklich*,' but is not open to the same objections on the grounds of animistic implications. We thus note that both neurological and psychological considerations of the problem of conscious action must give an account of the two factors mentioned in an earlier paragraph: the preparation for the act, and the release of the act.

The Function of the *Libido concept* in Reëducation

These two factors, the one for obtaining the preparation, the 'set,' the other for obtaining the release of action, enter into all successful systems of reëducation. For obtaining the first, psychoanalysis has developed a bit of technique of decided pragmatic worth. If we may criticize the method at the very point where it usually prides itself on being particularly effective, namely in its practice of 'analysis,' which reveals to the patient his pathological condition,—then we must in justice point out also that its dangers are offset by the fact that, in the process of 'analyzing,' the picture of the normal emerges as the ideal toward which the reëducation is moving. This emphasis upon the picture of the normal operates psychologically in the same way as does the '*Aufgabe*' in the psychological laboratory. It sets the organism for the new behavior in the same way as the instruction in the laboratory creates a specific determining tendency in the subject.

The second factor entering into the process of reëducation is the mechanism for inducing the 'activity attitude' that favors the release of the desired mode of behavior. It appears that psychoanalysis possesses in its conception of the *Libido* an instrument admirably adapted for preparing and releasing the efferent mechanisms. The problem always is: how can this motor preparation and this activity attitude be induced, so that the individual will not merely 'know the good,' but will also do it?

[1] Washburn, M. F., Movement and Mental Imagery, Boston and New York, 1916, 161 ff.

The methods by which this is effected in education, in social control, and in healing, are various. The presence or the absence of certain objects or persons may do it; or again, some posture of the body; or again, some suggestive idea. The hypnotist does it by suggesting: "You will do as I say." My twenty-year old neighbor-boy clinches it by a dynamic formula, hand-illumined by candle-light; it reads: "Look to your *pep*." The psalmist affirms simply: "I shall fear no evil," and the inhibitions are released and he marches on.

Indeed the history of man's attempt to gain control over self is the history of the search for a formula that will give faith to act out a vision, to try the untried. And one of the oldest of the methods by which the readiness and release of the efferent mechanisms is ensured, is the use of the idea of a force, or energy, or power, surging and resurging through the organism, constantly seeking expression; and if blocked at one point 'seeking exit'[1] at another. It is the image clinched in the *Libido* of Freud and Jung, in the *Élan vital* of Bergson, in the *Wille zur Macht* of Nietzsche. Few ideas can compare with this one for tuning the organism for action. It is an idea to conjure with. No one, for instance, can come away from a reading of White's book on the 'Mechanisms of Character Formation' without a feeling of the actuality of the cosmic urge at the root of life.

The further development of the elements that enter into this psychoanalytic concept, that functions so effectively in inducing the 'activity attitude' is exquisitely illustrated in White. He goes beyond Freud and makes additions to the picture that add greatly to its pragmatic value. Not only does he see, with Freud, 'the will to power, as a great creative energy, streaming through the body,'[2] pouring through its channels, seeking exit in the form of some overt act,—but he sees it also as being transmitted from person to person in the social relationships in ever-widening circles.[3] And he would further enrich the concept by incorporating certain other dy-

[1] White, W. A., Mechanisms of Character Formation, New York, 1916, 323.

[2] *Op. cit.*, 258.

[3] *Op. cit.*, 333. "The symbol is the vehicle for the carrying of energy from person to person."

namic elements that make it resemble closely the central conception of ancient religious faiths. By way of Fabre's spiders that lived for seven months apparently without taking food, he arrives at the hypothesis that the animal organism can utilize solar energy directly, without fixation by chlorophyl, —and then advances the suggestion that 'the hundreds of thousands of receptors at the surface of the body' constitute 'a real and material source of energy which has been, largely at least, overlooked,'[1] Just how the cutaneous receptors are supposed to function in the novel capacity assigned them, White does not inform us; and it is not our purpose to enter into a critique of this curious conception of the sensory mechanism as an energy-intake. But let us note that White's conception of the sun as a source of energy that the organism can draw upon directly, through its sense organs, reveals striking kinship with the central conception of the once mighty sun-faiths of Asia and America, in which the orb of heaven was worshipped as the Giver of Life.

While it is wholly unjustifiable on scientific grounds to regard the body's receptor-equipment as an energy-intake paralleling in function the respiratory and the alimentary organs,—the hypothesis is nevertheless significant as indicating the type of 'dynamic' concept that psychoanalysis as a method of healing is developing. It is entirely in the direction of that conception that historically has proved itself of great pragmatic value in the religions of the race: the conception of a cosmic energy that flows in from a great universal reservoir, is transmuted and directed within the individual human being, and then flows out to bless the lives of his fellows.

Both in content and function the psychoanalytic concept is very like that of a contemporary Celtic[2] healer who, without claiming to be scientific, writes: "And so the holy Thing of Life passes unto the soul of the patient, and through that soul, it ultimates in the healing of the diseased body. Thus it is that, by merely opening the soul to receive the Divine

[1] *Op. cit.*, 241 f.

[2] Macbeth, J., The Brotherhood of Healers, Chicago.

influx, you allow the holy Thing to pass through you to another. . . . I am moved often to utter mentally, while healing, the word 'Love,' and to keep uttering it so long as the will to utter it is in me; and this seems to bring me into perfect harmony with the one source of Life—the Sun of Divine Love. For all healers are children of the Sun."

This is all of a piece with some of the variants of the Freudian conception of the *Libido*, so warmly defended by its protagonists. And it reveals the secret of its pragmatic justification: it induces in the healer and the healed an attitude highly favorable for the process of neuro-muscular and neuro-glandular reëducation. For unless this requisite attitude is induced in the patient, no amount of analysis of abnormal action and thought, no amount of holding forth upon the normal as an ideal, will bring results. But if the psychoanalytic method has succeeded in creating, in the mind of the patient, an ideal of normal behavior as the goal of his efforts, which functions specifically in setting the psychophysical organism for the new behavior, in very much the same manner as does the '*Aufgabe*' or instruction in the psychological laboratory,—then the psychoanalyst's emphasis upon the idea of an effective psychic energy, the *Libido*, may be counted upon to create in the patient that faith or expectation, that 'activity attitude,' that psychology finds to be essential for the release of the specific overt response under the determining tendency created by the '*Aufgabe*.'

We must, however, distinguish between the content of the theoretical concept of the *Libido* in the systems of the psychoanalysts, and this its psychological function in the process of reëducation. We would call attention to its kinship with historical antecedents that have functioned similarly in man's practice of the art of healing throughout the ages. And finally we would point out that the psychological analysis of this function shows that the success of the psychoanalytic treatment, as of all other modes of psychic healing, is dependent in large measure upon the specific activity-attitude which it induces in the patient when he strengthens within himself the peculiarly effective belief that there is within and around

him an ever-present and never-failing supply of energy, upon which he can draw and thus re-create himself in body and in mind. In our modern world the naturalistic point of view has tended to crowd out the concepts of an earlier age when, through an Isaiah, the Ruler of the Universe invited the children of men to take hold of His strength, or when the psalmist petitioned: "Give Thy strength unto Thy servant,"—and forthwith the true believer was re-energized. Having crowded out these concepts with much flourish and noise, the contemporary world decks out other symbols in a pseudo-scientific terminology to serve the old, old need of keeping alive or re-awakening that faith that is the psychological prerequisite for healthy action.

Conclusion

In the course of our analysis of the psychoanalytic method four factors were found to enter into the process of psychic healing: (1) analysis of the disorder, (2) enthusiasm, (3) the formation of the ideal of behavior, and (4) the creation of the attitude that will favor reëducation. The Freudians, to be sure, have tended to ascribe much virtue to the first of these factors; yet it is doubtful whether the picture of the abnormal, revealed in the process of 'analysis' to the patient, constitutes the most vital element in the method. But whatever the virtue of the analysis and of the revelation of his pathological condition to the patient, during which there is always the danger that some of the very safe-guards which nature herself, according to Freud, has erected in the course of the normal development, may be broken down,—the other three factors are of greatest import. Nothing limbers up the neuro-muscular and neuro-glandular mechanisms like enthusiasm. It lowers the resistance in the little used paths and it disturbs and loosens the fixed pattern of the old sensori-motor circuits of the pathological behavior. Again, holding up the picture of the normal—which may be a bit of technique that psychoanalysis has stumbled upon rather than consciously developed—performs in the process of reëducation the same function that the *Aufgabe* performs in the psychological laboratory.

And finally, in the conception of a vital energy that, by simple redirection, may become potent for good performance as it was for evil, the psychoanalyst has come upon a venerable and proven device for restoring the necessary faith that puts go and punch into the new behavior. If it frees the spirit from the fetters of fear and sin, from morbid gloating over abnormal symptoms and from sickly sentimental contemplation of the ideal of physical and moral health, and if it pulls the organism out of the rut of the old pathological behavior of nerve and muscle and gland,—if it does these things and so long as it does them, no concept, whether it be clinched in the term *Libido*, or *Wille zur Macht*, or *Élan vital*, or Divine Power, needs apology. It would be well, however, if both user and critic would distinguish between the scientific content of the concept and this its stimulus-value as a releaser of energy.

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